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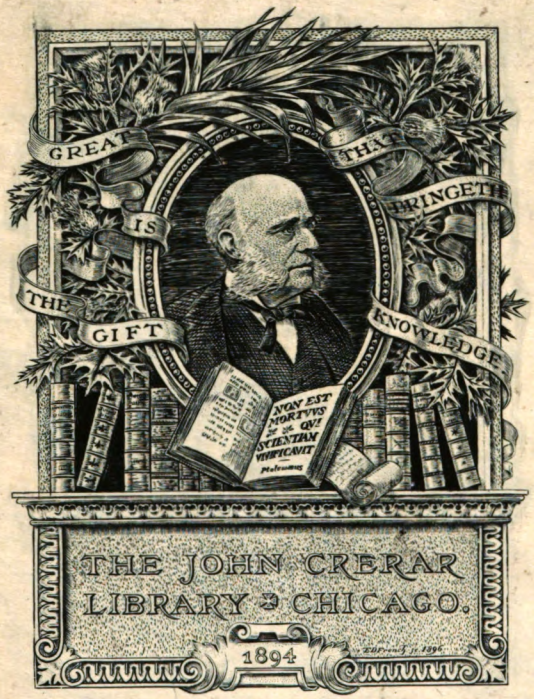

PRESENTED BY

The Secretary.

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Report of the Fifty-Fifth Meeting
OF THE
Eastern Association of Physics Teachers

SATURDAY, MARCH 19, 1910
ROXBURY LATIN SCHOOL, BOSTON, MASS.

PROGRAMME.

9:30 *A. M.*
Meeting of Executive Committee.

10:00 *A. M.*
Business Meeting.
1. Reports of Secretary and Treasurer.
2. Election of New Members.
3. Election of Officers.
4. Reports of Standing Committees.

11:00 *A. M.*
Gallileo in *Florence* and *Rome*, by Mr. J. C. Packard.

11:15 *A. M.*
New Apparatus and *Devices* found useful in teaching *Mechanics*, by Messrs. Andrews, G. A. Cowen, Gilley, Hathaway, E. Rice, A. G. Webster.

12:00 *M.*
An *Elementary Course* in *Practical Mechanics*, by Prof. J. M. Jameson, Pratt Institute, Brooklyn, N. Y.

1:00 *P. M.*
Luncheon.

2:30 *P. M.*
The Gyroscope, how it works and what it is used for, by Prof. A. G. Webster, Clark University, Worcester.

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Proceedings of the Meeting of the E. A. P. T.

Roxbury Latin School, Boston, Mass.

March 19, 1910

The fifty-fifth meeting was called to order by the president, Mr. N. Henry Black, and the secretary's printed report of the last meeting was accepted.

This being the annual meeting the secretary's annual report was read as follows:

Annual Report of the Secretary.

Three regular meetings have been held during the past year at the following places: Franklin Union, Boston, Mass., Jan. 23, 1909; Public High School, Hartford, Conn., April 24, 1909; Boston City Club, Nov. 19, and Harvard University, Nov. 20, 1909. At these meetings the Association has been addressed by the following speakers: Prof. Louis Derr, Massachusetts Institute of Technology; Mr. Walter B. Russell, Director of the Franklin Union, Boston; Mr. Frank M. Greenlaw of Newport and Prof. W. F. Magie, Princeton University. Valuable papers and reviews have been given during the year by W. F. Rice, C. A. Andrews, F. M. Gilley, Prof. E. H. Hall of Cambridge, Prof. F. A. Waterman, Northampton, Irving H. Upton, Miss Grace MacLeod, J. C. Packard, Lyman G. Smith and Frederick G. Jackson, all members of the Association. At the Hartford meeting the Association listened to excellent papers by the following members of the Physics Club of New York: Frank B. Spalding, W. G. Whitman, John A. Clark, and Raymond Brownlee.

The committees have been prompt in presenting full reports at the meetings. Upon the recommendation of the Committee on Foreign Relations three foreign correspondents have been appointed, two in Germany and one in England.

A course in Steam Engines is being given at the Franklin Union for members of the Association by Prof. Reed of the Worcester Polytechnic Institute.

An effort has been made to increase the membership by sending out circulars. The results indicate that the best way to fill the ranks with desirable members is through personal influence. There are some changes in the roll. Five active and five associate members have resigned; one has been transferred from active to associate membership, and three from associate to active membership; three active and seven associate members have been elected. One member has died.

The present enrollment is seventy-seven active, sixty-nine associate, and two honorary. The total, one hundred and forty-eight, is one less than that of last year.

Respectfully submitted, FRED H. COWAN, Secretary.

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This was followed by the annual report of the treasurer.

Annual Report of the Treasurer.

RECEIPTS.

Balance January 23, 1909	$169.03
Dues for 1908	.75
Dues for 1909	50.50
Dues for 1910	291.00
Lunches	24.00
Subscriptions to School Science and Mathematics	99.02
Subscriptions to Scientific American and Supplement	59.00
Subscriptions to Technical World	8.00
Subscriptions to Electrician and Mechanic	3.90
Sale of reports, etc.	5.30
From N. Y. Association for reports of Hartford Meeting	18.64
Total	$729.14

EXPENSES.

Expense of Franklin Institute Meeting	$ 2.00
Expense of Cambridge Meeting	15.50
Secretary's expenses, clerical help	25.00
Secretary's expenses, postage, etc.	19.24
Lunches	27.00
Printing of three reports	159.50
Printing of Manual	20.00
Printing of notices, stamped envelopes, etc.	84.68
Subscriptions to School Science and Mathematics	102.10
Subscriptions to Scientific American and Supplement	61.50
Subscription to Technical World	8.00
Subscriptions to Electrician and Mechanic	3.90
Balance, March 19, 1910	200.72
Total	$729.14

Respectfully submitted,
PERCY S. BRAYTON, Treasurer.

Auditor's Approval.

I have examined the accounts of the treasurer, and find the receipts and expenditures properly accounted for, and the balance on hand $200.72.

CLARENCE BOYLSTON, Auditor.

March 19, 1910.

Mr. Brayton, at the close of his report, stated that the number of members availing themselves of the club rates for magazines is increasing. He believes this important work of the Association should be extended.

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After the reading and acceptance of these reports, the first item of business was the election of

NEW MEMBERS.

On nomination of the Executive Committee the following new members were elected:

Active,

Frederic H. Sawyer, Rindge Manual Training School, Cambridge, Mass.

J. C. Moore, Worcester Academy, Worcester, Mass.

Winthrop E. Fiske, Phillips Exeter Academy, Exeter, N. H.

Associate,

Edward Smith, High School, Attleboro, Mass.

Harriet B. Lord, High School, Revere, Mass.

Sydna E. Pritchard, High School, Northampton, Mass.

It was then voted, on recommendation of the Executive Committee, to make William H. Snyder, High School, Hollywood, California, an honorary member, and Prof. E. Grinsehl, Direktor der Oberrealschule auf der Uhlenorft in Hamburg, a foreign correspondent.

These resignations were announced:

William Mahin, Denver, Colorado.

Arthur C. Palmer, Pomfret School, Pomfret, Conn.

Eugene M. Dow, Volkmann School, Boston, Mass.

Frederick C. Adams, Mechanic Arts High School, Boston, Mass.

According to custom, first an informal and then a formal ballot was taken for the officers for the ensuing year. The ballot resulted as follows:

President—Frank M. Greenlaw, Newport, R. I.

Vice-President—C. S. Griswold, Groton, Mass.

Secretary—Ralph W. Channell, Malden, Mass.

Treasurer—Percy S. Brayton, Medford, Mass.

Executive Committee—the foregoing ex-officio and N. Henry Black, Roxbury, Mass.; Fred R. Miller, Newton Highlands, Mass.; Calvin H. Andrews, Worcester, Mass.

It was voted that an appropriation of $30 be placed in the hands of the secretary for his use.

The Association then passed a vote of thanks to Mr. Cowan for his careful service as secretary during the past year.

Reports of standing committees were now called for, but owing to the lateness of the hour the report of the Committee on New Apparatus was deferred until after luncheon.

Mr. Charles R. Herrick, chairman of committee, owing to illness, was not able to present a Report of the Committee on Magazine Literature.

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Mr. Roger C. Chittenden, chairman of committee, gave the following:

Report of the Committee on Current Events in Physics.

The non-magnetic yacht "Carnegie" has returned from a voyage of 8000 miles. During her trip across the Atlantic errors were found in the best magnetic charts now in use.

At the Solar Observatory in California it is expected that an investigation of the electro-magnetic properties shown by the sun, in conjunction with observations made by the Department of Terrestrial Magnetism on "storms," to which the earth's magnetism is subject, will result in a distinct advance.

Arrangements have been perfected between Captain Roald Amundsen and the Department of Terrestrial Magnetism, regarding co-operation in magnetic work on the proposed polar expedition to leave Norway this summer on Nansen's vessel, the Fram.

The Langley medal, in honor of the late Dr. S. P. Langley, has been awarded to Orville and Wilbur Wright.

Lord Rayleigh has been elected a foreign associate of the Paris Academy of Sciences to succeed the late Simon Newcomb.

An ice plant capable of producing 70 tons daily was erected last summer by an American company at Smyrna, Asia Minor.

The latest German passenger airship Parseval V. covered 80 miles safely in four hours on March 1. Various European nations now have a total of 32 dirigibles and 56 aeroplanes available for service.

An ingenious instrument for recording the speed and license number of an automobile has been invented. Its main features are a camera and a stop watch. Two photographs (taken from the rear) are snapped and the speed worked out from the time interval and relative sizes of the images.

Practically the whole of the business of the big telegraph companies is today sent by the hand-operated Morse key. The average speed is about 50 words per minute. Various European inventors, Hughes, Murray, Pollak-Virag and Delany claim speeds of from 4,500 to 60,000 words per hour.

The Government is fitting the Indiana with emergency brakes. These are steel wings 5 feet wide by 18 feet high which fold against the ship. A lever on the bridge releases a clutch and the water opens the wings against pneumatic cushions. One may be released at a time to turn the boat and both together will stop it in half its length.

Louis Brenan of England has a successful monorail car 40 feet long and 10 feet wide. It is equipped with two gyroscopes

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having 3000 revolutions per minute, each weighing one and a half tons.

Black light is a curious term used by Gustave Le Bon of the French Academy of Sciences, to describe a form of radiant energy which arises from the back of a thin sheet of opaque metal when the front is illuminated with ordinary light. In some of its properties "black light" resembles the X-rays.

The Westinghouse Company of Paris is constructing apparatus for the domestic sterilization of water by means of the ultra-violet rays from a mercury vapor lamp. At 110 volts and 3 amperes a lamp can sterilize from 400 to 1200 liters of water per hour.

Mr. Augustus Rosenberg describes an electro-chemical method of plating metals. "Galvanite" is a dry granular powder consisting of various intimately mixed principal and secondary ingredients according to the metal to be deposited. "Galvanite" may be sprinkled on a damp cloth and applied like any metal polish. No cleaning of the parts is required and local currents are set up which actually deposit pure metal electro-chemically.

A company called the Fixed Price Light Co. has been formed in England under the auspices of the Messrs. Siemens to supply small houses with electricity at a fixed rental of from five to seven cents per week per lamp. The houses are wired on the concentric "Stannos" system, the outer sheath serving as return conductor. Sixty volts are supplied to sockets made to fit only a special form of Tantalum lamp.

Sir Hiram Maxim has fitted his new aeroplane with a special engine of which much is expected. It is a 4-cylinder, 80 H. P. engine and weighs complete 220 lbs. There are two large and one small screw.

The fifth of the international balloon races will be held this fall at St. Louis.

The Alps show an extraordinary attraction for Hertzian wave currents. Military experiments have proved conclusively that Switzerland can intercept any wireless messages within a radius of 2000 miles.

The North British Locomotive Co. of Glasgow is building a turbo-electric locomotive for express service which is expected to be more economical and efficient than the steam locomotive.

George J. Coles and Joseph Silver have invented a solder for Aluminum which the Mass. Institute of Technology has tested to withstand a pressure of 6,634 lbs. per square inch. Its electrical resistance is practically the same as that of pure aluminum. A company has been incorporated and the solder may be seen at 199 Berkeley Street, Boston.

ROGER C. CHITTENDEN, Chairman.

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Mr. John W. Hutchins presented the following:

Preliminary Report of the Committee to Investigate the Teaching of Physics in Small High Schools.

Under the direction of this committee a very careful investigation of the facilities of the smaller high schools in New England to conduct profitable courses in Physics has been conducted. The data collected from nearly 200 schools shows the time given to recitation and laboratory work, the value of laboratory equipment, the teacher's preparation for his work, the place of the subject in the school curriculum, the number of pupils pursuing courses in Physics, its importance as a college entrance subject, and other data.

A summary of this data and some conclusions were drawn.

The report also included several recommendations as to the conduct of courses in this subject. In accordance with the vote of the Association this report will be presented later in print, with accompanying tables, which the committee hopes may be of service.

JOHN W. HUTCHINS, Chairman.

It was voted to continue the committee and to request a report if possible, at the next meeting.

Mr. J. C. Packard of the Brookline High School now addressed the Association on:

Galileo in Florence and Rome.

Mr. J. C. Packard:—

Mr. Packard told many of the things he, himself, learned in regard to Galileo in Florence, Pisa, Venice, and Rome. The account of his visit to the tomb of Galileo, to the Leaning Tower of Pisa, and in fact his whole address was full of life, and intensely interesting. He read selections from "Galileo, His Life and Works," by J. J. Fahie. This book was recommended as a very interesting book to read. It contains many excellent illustrations.

Prof. J. M. Jameson, Pratt Institute, Brooklyn, N. Y., gave an address on:

An Elementary Course in Practical Mechanics.

Prof. Jameson:—

Rapid changes are taking place in the aims and methods of secondary education. A movement toward industrial education is sweeping over the country, demanding that in its system of public instruction, each community shall make provision for schools which have as their chief aim vocational training such as shall send young men and young women out into the industrial world equipped to play an efficient and creative part. This movement is focusing the attention of both public and school men upon our High Schools, and is bringing not only school programs but the syllabi of particular subjects under searching scrutiny. As an outcome, quite apart from

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the question of the need for specially equipped industrial schools, many teachers and executives are coming to feel more and more strongly that the real problem before our Public High Schools which has not yet been solved in a satisfactory manner, is the question of the best good of the 90 per cent. or more of the Public School pupils, who through stress of circumstances or through lack of taste or aptitude for purely academic study, leave school at the conclusion of their Grammar School course, or at most after one or two years of High School study, to go out as wage earners in the industrial world.

We physics teachers have felt the stirrings of the same great educational movement. Indeed, I might say that we have in many cases anticipated it. We have from the first been wholly confident of the value of our subject, viewed either from the informational or from the moral and disciplinary side. We know that no other subject is more intimately connected with life, or with what we so often hear characterized by the very inclusive terms "human progress" and "civilization," and we are ready to insist, or at least I for one am ready to insist that the past expenditure for laboratories and equipment has been justified, and that at no previous time has physics teaching been more fully organized. Yet we are not fully satisfied with the results that we are securing. Why is it that our Secondary Schools so often fail to hold the interest of young men as soon as they reach an age at which they begin to plan for the future? Why is it that High School graduates do not rank so far above and beyond those who have received less training, that pupils and parents are not willing to undergo any sacrifice, no matter how great or how prolonged in order that they may remain throughout the High School course? And wherein and for what reasons has physics to assume a share of responsibility for these conditions? The reasons, in my judgment, are few and not far to seek.

In the first place, while we may believe in the intimate connection of our subject with the pupil's daily life and interest, we do not really make such connection *often enough or fully enough.* Too many of our laboratory exercises are adopted from the College or University list by merely stripping the apparatus of its high precision and difficulty of manipulation until elementary students can "go through the motions." The operations are possible to high school pupils: the ideas are still those of the University, and are suited only to the specialist in physical science. They are capable of arousing a compelling interest only in a mature mind interested primarily in the subject. They can never by any stretch of imagination or through any amount of "drill" on the part of the conscientious teacher produce such a result upon the mind of the average boy or girl. Secondary School teachers of physics have been too afraid to cut loose from leading strings. Our problem is not physics

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as physics; it is just boys as boys and girls as girls. We may just as well save time and energy by recognizing it at once.

Now the starting point for any boy (or girl either for that matter) who is interested in *ideas* is mechanics; provided only it is mechanics of the fundamental principles and processes which the boy sees and wonders about every day of his life, and not a series of mathematical demonstrations. Teachers of Secondary School physics have too often cut down the time given to mechanics. They have failed to appreciate the possibilities of the subject both for class room and laboratory, and have wandered away after the more "striking" and so called "interesting" subjects of sound and light.

For more than twelve years now, we of the Physics Department at Pratt Institute have been endeavoring to develop a course of instruction in mechanics which shall not only bring out the larger and more fundamental ideas of the subject, but which shall, at the same time, *apply these ideas* to structures and processes of real interest and value which are within the student's range of observation and comprehension. You do not need to remind me that students of a Technical School differ from those of the usual Secondary School. Before teaching physics at Pratt Institute, I taught physics to High School boys and High School girls. But we have found out through trial certain things in the matter of teaching mechanics, and some of these experiences I am convinced apply equally strongly to purely Secondary School physics. In the first place, we have found the necessity for carefully building up *a few central ideas and principles*—the fewer the better if adequate—around which other necessary ideas could be grouped, a sort of central frame work with pegs, if you please, on which to hang other related ideas as they arise. The tendency in physics teaching is to present too many unrelated and unattached ideas, and to teach particular cases rather than broad general principles. In the second place, we have come more and more to appreciate the value of *intuition* as opposed to rigorous demonstration. If a thing is perfectly clear to a student's mind, if he really comprehends it and can use it with intelligence and certainty, why in an elementary stage of teaching, require him to go through the proof? The simplest things are often the hardest to prove. Why waste time and confuse students by compelling them to go through a round about process of proof, which is often all *our* way of thinking, not theirs, when the whole matter is perfectly clear and acceptable to their minds and does not, unless we first suggest it, present any special difficulties, or raise any question of doubt? For example, why stop to demonstrate by a special exercise, the pressure on the support of a lever? Every boy knows that lever and weights must be held up by something. He will tell you very readily in response to the direct question what the pressure on the support

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must be. Or why demonstrate as a separate exercise the effect of the weight of a lever? All real levers have weight. Let the student rather get a habit of putting in weights of parts as simply so many extra forces. His results will always come out all right, and what more is required? Why has he not the essentials of the whole matter? Above all we must not measure the value of a particular exercise by the difficulty the boy has in delivering a correct report upon it. That may be a matter in which we are at fault and not a question of his stupidity or lack. Perhaps his mind does not run in the channels in which ours has settled.

And finally, we have found it desirable to plunge into the heart of a problem without losing all the interest and excitement in preparatory exercises teaching this or that abstraction. This method of attacking things in the large I wish particularly to emphasize. It saves much time, it holds interest, and it gets results. We so often do not give our pupils credit for half the common sense and initiative that they really possess. We would not think of undertaking an every day task or business proposition with them in the same way as we approach our physics laboratory work. We would treat them as really thinking beings, capable of having at least ocasional flashes of intelligence, and nine times out of ten they would rise to the occasion. Being treated as intelligent they act intelligently; when we assume they are stupid—or what amounts to much the same thing—as incapable of reasonable initiative and freedom of thought, they naturally feel called upon to act the part.

Laboratory exercises and problems in physics should be approached in much the same way as we would undertake a construction job with students as workmen. The problem should be big enough, and the apparatus and conditions should be attractive enough to inspire interest and respect. Above all, we should cast such abominations and interest killers as so called "Exercises in Measurements" out of the Physics Class Room and Laboratory. Of what possible interest to measure or weigh an object to the highest possible degree of precision if that object is then to be thrown back into the junk drawer to lie in wait for the next poor unfortunate and no further use or value is to be attached to the results obtained? The time to measure a length is when that length is required for definite use, as for example, a moment arm, the height of a mercury column, the length of a beam, or a wire under tension, etc. The time to learn the principle and use of the micrometer is when it is required for measuring a necessary value, as the expansion of a rod by heat, the deflection of a beam, etc.: and the time to learn to use a vernier is when required to read a barometer or other vernier instruments. And these also, are the occasions on which to call attention to the degree of precision required in different operations and the use of significant figures in expressing

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the extent to which we may really rely upon our result. We not only fail to teach our students all we should, but we are doing them positive harm when we permit them to weigh the water in a calorimeter to 1/100 of one per cent. when they cannot possibly determine temperature change to better than two or three per cent., or when we accept a PV product carried to seven significant figures or a modulus of elasticity expressed to four decimal places.

And now as to some of the central ideas of mechanics to which I referred a moment ago, about which we are to group our related ideas. These, I repeat, should be as few as possible, and the more elementary the work the greater the necessity for selecting the right few. I would place first a real conception of what we mean by force when speaking of some actual structure—and we ought always to have before us some actual, well-known object or device for our discussion. You may make any elementary definition of force that satisfies you; but do not fail to bring out the fact that what we term force emanates from some other body influencing the one under discussion. Forces are the pushes, or pulls, or rubbing, or pressure, or attraction, etc., of one body on another; and when body A exerts a force on body B, body B exerts an equal, opposite and simultaneous action on body A. We have always to deal with two actions, or an action and a reaction. Which we are to use depends upon the body we are discussing. It is important in practical mechanics that *both* should be held in mind. For example, suppose we are speaking of the door yonder. There is a force exerted by the door at each hinge, there is always also the equal and opposite action of the hinge upon the door. Which we are concerned with depends upon whether we are discussing the door or the hinge. And having obtained this ability to use the term *force* in a real sense, provides practice in constructing qualitative diagrams of force conditions in which forces are introduced in the proper sense as to two of their three attributes, viz., direction and point of application.

(BLACKBOARD ILLUSTRATION, FORCE ON JIB OF A DERRICK; FLOOR BEAM, ETC.)

This is the first step toward actual accomplishment in mechanics. When the student is able to picture to himself, the arrangement of forces with which he is dealing, not *until then*, is he ready to apply in an intelligent way his parallelogram law, or his parallel force laws, etc., as the case may require.

Having then acquired this ability to place clearly before himself for consideration, the conditions of the problem with which he is dealing, the next step may be to consider what is the natural effect of these conditions. In statics, the function of any particular member of a structure, as a truss or a derrick, is to hold in place the other members when a load is applied to the structure. It in turn is acted upon by a system of forces coming from the other

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members in contact with it. If our structure is to hold, the total effect of all external actions must be such that the members may each be held rigidly at rest. Now what are the ways in which a member could get out of this existing condition of rest? Let us take, for example, this book which we will assume is held here in space by external forces applied to it. In what way may this book change from its existing condition, that is, from rest? Naturally, if the forces on it pulling toward the right exceed the forces pulling toward the left, it will move toward the right, and vice-versa. If the forces pulling upward exceed those pulling downward, it will move upward. If the moment of forces tending to turn it in the same direction as the hands of a clock exceeds that tending to turn it in a contrary direction, it will rotate in that direction, and vice-versa. It appears then that in order that it may continue in its existing condition, which we have said is one of rest, the forces to the right must balance the forces to the left; the forces up must balance the forces down; and the moments of forces turning clockwise must balance the moments of forces turning it counterclockwise, or as we may summarize it briefly the conditions must be such that:

$$\text{Sum } X = 0$$
$$\text{Sum } Y = 0$$
$$\text{Sum } Pa = 0$$

Here we have arrived at all there is to the statics of bodies under the action of forces in one plane. Having established these fundamental ideas which we may call the axioms of statics, we may apply them at will to many practical determinations, just as with a few fundamental axioms we may build up a science of mathematics by means of which we may carry on extended computations. Now let us teach our statics from this point of view as all coming back to one set of definite fundamental conditions which universally apply, and not as a series of non-related ideas.

For example, in a simple wall bracket consisting of a horizontal compression member pinned at one end and having the outer end supported by a tension member running upward and to the left to a point vertically above the pin; when a load is hung from the end the forces are as shown by the arrows. (See BLACKBOARD DIAGRAM). We may, therefore, apply the parallelogram law of forces directly for a graphical solution or even better, may resolve the force in the tension member into its vertical and horizontal components and may then apply our algebraic conditions for equilibrium, Sum $X = 0$ and Sum $Y = 0$. Since the forces meet in a common point, the moment arms with respect to an axis through this point are zero, and our third condition reduces to the form $0 = 0$.

In a system of parallel forces, as in a floor beam with loads (SEE BLACKBOARD DIAGRAM FIG. 2), the forces being parallel lie all in one axis, or Sum $X = 0$, becomes $0 = 0$, and we may

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apply our other two fundamental conditions for the usual laws for parallel forces: "Algebraic Sum of all forces = O", (2) "Algebraic sum of the moments of all forces about any axis=O." Weight of beam is included as simply another force to be considered. It should be pointed out and demonstrated by computation that the moment equation is true for an axis situated at *any point* along the axis of the beam.

Or finally, in the system of forces for the jib of a derrick (SEE BLACKBOARD DIAGRAM FIG. 3), where the forces do not pass through a common point and are not parallel, the same three fundamental conditions apply, and for a full solution of a given case we must use all three.

I give these three illustrations at some length, not that in themselves they present any new method as to solution, but because they bring out the point which I am trying to make, that in an elementary course we should teach general, not special, principles. We see that cases of concurrent, parallel, and non-concurrent forces—all of elementary statics if you please—may be referred back to *the same fundamental conditions* of balanced tendencies to translation and rotation respectively. By so teaching them, the pupil has his subject unified. He learns one general procedure or method of attack for all cases, and hence acquires confidence and is not easily confused. Drill upon one becomes in a sense drill upon all, and hence, even in the short time permitted by high school programs, the average boy acquires considerable ability in solving common and practical problems in statics. If so, I submit that he knows *more really usable mechanics* than would come from any smattering of special and unrelated ideas. He certainly can dispense with such an absurd classification as levers of the first, second, and third class.

A similar method of presentation I have found most successful in teaching the mechanics of moving bodies. Suppose the pupil picks out all the forces acting upon the body in question and represents them by a simple diagram; then as he inspects them, if all forces in any given direction are opposed by an equal total of forces in the opposite direction, the condition is one of equilibrium. In other words, there is nothing to disturb the existing state, and hence if the body is originally at rest it will remain at rest; if moving, it will continue to move in the same direction and at the same rate. The pupil readily sees therefore that uniform motion of translation or rotation is a condition of equilibrium, or, as we say, of balanced forces. If, however, the forces in any direction exceed those opposing, accelerated motion will occur. Since, however, the reaction due to inertia is equal and opposite to the unbalanced force, we may here also sum up all the actions tending to produce motion and equate them to all the actions tending to oppose motion, *always putting among the latter one, due to inertia or equal to* $\frac{Wa}{g}$.

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This scheme of presenting accelerated motion in the same form of statement as used previously in statics, that is, by the simple "reaction equal and opposite to action" expression, I have found most helpful. In the first place, the "*Acceleration Diagrams*," as I have termed them, put the conditions clearly before the student, and tend to prevent the omission of important factors; and secondly,—a matter of great advantage in a short and elementary course—a uniform method of attack is adhered to throughout the whole subject of mechanics.

As an illustration of the "Accelerated Diagram," suppose we have the case of a cord passing over a pulley and carrying weights, one of 34 and one of 30 pounds. Assume mass of pulley and cord as negligible and friction of pulley as 2 lbs. (SEE BLACKBOARD DIAGRAM FIG. 4.) Motion will evidently be downward on the 34 lb. side, upward on the 30 lb. side, or writing our equation:

"Sum of all actions in the direction of motion=Sum of all reactions opposing—we have $34 = 30$ plus 2 plus $\frac{64}{32}$ a, from which $a = 1$ ft. per sec2. And calling T1 the tension on the 34 lb. side, and considering the above equation for 34 lb. weight alone, we have $34 = T1$ plus $\frac{34}{32} \times 1$, or $T1 = 32.9$ lbs. approximately. The similar equation for T2, the tension on the 30 lb. side is: $T2 = 30$ plus $\frac{30}{32} \times 1$ or $T2 = 30.9$ lbs. approximately. $T1 - T2 = 2$ lbs., the assumed value for friction. These equations are typical of those for the tension in hoisting ropes, etc., when starting or stopping a suspended body. By consistently adhering to this simple form of statement, the forces involved in apparently complicated cases of acceleration may be readily determined.

Owing to the importance and common occurrence in practical operations of accelerated motion of rotation, such as the starting and stopping of machinery, some instruction ought to be given on this subject even in elementary courses in practical mechanics. At least the torque due to driving belts and the nature of the reactions against which it operates should be pointed out. This soon leads us into notions of *Moment of inertia*, etc., conceptions which are somewhat beyond an elementary course in mechanics. I have found the following method of presenting this idea, however, successful and reasonably free from any great difficulty. Suppose a heavy flywheel of weight W is caused to change speed by means of a force F applied by a belt running over a pulley of radius d ft. (SEE BLACKBOARD DIAGRAM FIG. 5.) The driving torque is then Fd pound-feet. At some distance from the axis as Ao the speed will be such that if all the weight W of the flywheel were situated at this point the effect of the rotational inertia would be equivalent to that of the actual wheel with weight W distributed between axis and rim. Let Ao be the *linear* acceleration in ft. sec.2 along the circular path at this distance from the axis. For any

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instant this acceleration will be in a straight line, and the "inertia reaction" may therefore be said to be $\frac{WA_o}{g}$. This reacts on an arm r_o, hence the moment of this reaction about the axis is $\frac{W}{g} A_o r_o$. And since driving torque equals reacting torque $Fd = \frac{W}{g} A_o r_o$, or since $A_o = 2\pi r_o A_r$, $Fd = \frac{W}{g} 2\pi A_r r_o^2$, where Ar is the acceleration in revolutions per second each second. For flywheels r_0 may for practical purposes, be taken as equal to the mean radius of the rim.

I have endeavored in the preceding to make a few definite suggestions of the methods I have found useful in teaching statics and the mechanics of moving bodies in a practical way. There remain the very important group of ideas relating to Work, Energy, Power, Friction, and Efficiency of machines and mechanical processes. These, I believe, should be approached through the laboratory exercises. The laboratory for teaching practical mechanics should be equipped with a variety of simple belted and geared machines, with pulleys and shafting, with jackscrews, hoisting tackle, etc. These should be commercial in character, and not the usual cone-bearing, delicate affairs of the physics laboratory. They should be large enough to inspire interest and respect. The usual experiment in efficiency of the College Preparatory Course—that of a system of pulleys, small, accurately balanced and operated by a thin cord lifting a few ounces—appears to me as most ridiculous. The experiment is all right, but let it be performed with a commercial block and tackle and rope not less than ½" and lifting from one to two hundred pounds. The results would then be of some interest and practical value.

By experiment with such equipment, ideas of work, of energy supply and transformation, of the conservation of energy, and of the efficiency of various devices and operations may be given a real significance. Under our modern conditions of life, in which the highest efficiency is demanded in both mechanical and human processes, such instruction can hardly be over emphasized. The related ideas also tend in the highest degree to develop initiative and a right attitude of mind toward the practical affairs and methods of business and industrial life.

The paper was then illustrated by lantern slides showing suggestions for the arrangement and use of models of various practical structures, as roof trusses, derricks, shear legs, etc., in teaching statics, and of various mechanical devices, such as a bicycle sprocket and chain, screw jack, simple belted and geared machines, shafting, etc., for use in teaching subjects of energy transmission and efficiency. It was insisted that these should be large enough to be of actual interest, and that they should be commercial in character. Where possible, some of the machines should be motor driven and the output be measured by a simple prony brake, thus

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giving practice under actual running conditions. It is not necessary that many duplicates should be provided with apparatus of this character. The pupils would work in larger groups, and a single piece of apparatus would frequently serve for four or five pupils. It is not necessary that each student should experiment with every piece of equipment. Much would be learned from merely observing the apparatus in operation about the laboratory and from class room discussions of the work of the class.

In closing, Prof. Jameson said he would be pleased to send blue prints to any one interested in constructing any particular piece of apparatus described by him.

Prof. Jameson's book, *Elementary Practical Mechanics*, contains some very valuable matter. It is published by Longmans, Green & Co.

An excellent luncheon was now served, after which the following men presented

A Report of the Committee on New Apparatus.

Mr. Andrews:—

A wooden pendulum carrying a piece of carbon paper is held back by a string which, after passing through two pulleys, holds an iron ball so suspended that the swinging pendulum hits the falling ball, making a mark. The distance covered by the ball and the time are easily obtained, and from these the value of g. The device is an adaptation of "Whiting's Apparatus."

He also showed a simple apparatus for determining mass without weight.

Mr. Hathaway:—

He exhibited a meter stick pivoted at the centre on a nail driven into some convenient support. The stick carries a rider, if necessary, to keep the balance. With the aid of a few weights and a spring-balance exercises on the lever are easily performed. Similar work, he showed, can be done with a 30 cm. rule pivoted on a nail driven into a cherry block. The rider may be used here as in the case of the meter stick. The main advantage in this apparatus is that the lever experiments thus performed require no additional apparatus.

Mr. E. Rice:—

Archimedes' Principle—Use of a Burette for Determining Volume.

A burette graduated to 1 cc. is used. For a heavy object a short length of ¼ in. brassed iron rod is weighed in air and water by horn pan balances, and its volume found by means of the burette. The error need not exceed 1 per cent. For a light object use a slender cylinder of wood, tapering at one end and weighted with

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lead shot at the other until the tapering end only shows above water when floated in the burette.

Another device for securing equal volume is to use two vessels of glass of same internal capacity; one is filled with melted sulphur. On cooling the glass is cracked and broken away, leaving the sulphur. The loss of weight of the sulphur is then compared with the weight of the water contained in the first vessel.

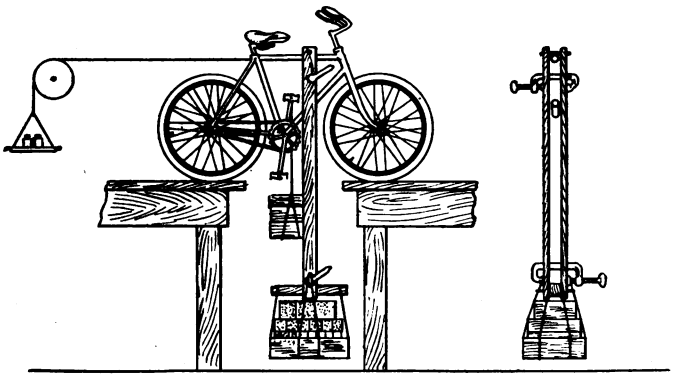
Prof. Hall:—

A convenient form of spring-balance was shown. The scale reads to 500 grams and to 18 ounces, divided into tenths. A long slit makes a correction for horizontal reading easy and a double pointed index gives a sharp reading. A large order would reduce the cost to about one dollar. Mr. Hall would be pleased to know of any who would likely order such a balance.

Prof. Hall also showed an interesting electrolytic cell illustrating occlusion. The electrocles are of platinum and palladium and the solution is dilute sulphuric acid. Oxygen appears at the anode, but hydrogen, instead of escaping at the cathode, is absorbed by the palladium and the wire becomes bent. When the current is reversed, hydrogen is removed from the palladium and the wire straightens out.

Mr. Martin:—

Determination of the Efficiency of a Bicycle.



The Wheel is placed across the space between two tables as in Fig. I. A bar AB, 54 in. long, is rigidly attached to the frame and held in place by the bolt H, and a clamp C. (Fig. 2). To the lower end of AB is bolted a cross-piece from which is suspended a box containing about 20 bricks, weighing approximately 110 lbs. These bricks serve to keep the bicycle erect as well as to take the place of the weight of a rider.

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A light cord K, attached to the frame beneath the saddle, passes over a pulley G and supports a scale pan R. The pulley G is mounted on a shaft having roller-bearings, made from the wheels of the little cars used in the inclined plane experiment.

The circumference of the rear wheel is marked off into equal parts, six to eight inches in length (1, 2, 3, etc.) such that 1 is at O, directly below the axle of the wheel when the pedal P is at its highest point.

A weight W (about 35-40 lbs.) is attached to the pedal P and several bricks are hung on a clamp E on the opposite side of AB in such a manner as to cause the wheel to stand without tipping.

When P is at its highest point, there is no pull on the cord K. The rear wheel is then raised and 2 is brought to O. Weights are added to R until the bicycle is just able to lift the pan R and its load. This weight is recorded. In succession, 3, 4, 5, etc., are brought to O and the greatest weight to the nearest 50 grams which the wheel will raise, not balance, is recorded in each case. This procedure is continued until P has reached its lowest point. During the experiment it is usually necessary to shift some of the bricks at D and F in order to keep the wheel upright as W drops.

Measure the distance which W has dropped, the distance which the bicycle would move on the floor while P drops from its highest position to its lowest. Weigh W, and take the average of the weights at R, including the two values of zero when P is at the top and at the bottom.

The work done upon the bicycle is the product of W by the distance through which it drops. The work done by the bicycle is the tractive effort measured by R multiplied by the distance which the wheel will move under the action of W. The efficiency is calculated as usual.

The values at R will be found to increase until P is on a level with the crank shaft. Owing to a difference in the friction of the chain at different points, these values do not always increase to the maximum or diminish from the maximum regularly. For this reason it is best to perform the experiment several times and average the results.

Different results will be obtained if the tire of the rear wheel is flat. Boxes containing sand, loam, gravel, or slime may be placed under the rear wheel if it is desired to vary the conditions. The effect of different loads may be found by adding to the weight in D. It may seem desirable to use a larger mass at W, in which case it will be necessary to increase the mass at D and the mass at F.

A spring dynamometer may be substituted for the pan and weights of R, but I have found that the weights give better satisfaction.

HAROLD C. MARTIN,
Peabody (Mass.) High School.

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Mr. Hall:—

Centrifugal Force Apparatus.

This is a device for verifying the formula for centrifugal force.

It consists of a vertical spindle driven by hand wheel or electric motor, whose speed can be varied. On the spindle is a speedometer and at the top an arm carrying a small mass arranged to slide radially on a wire.

The mass is connected by a string passing over a fixed pulley on the arm, to a swivel joint over the axis of rotation, thence to a spring balance.

As the mass revolves, it slides out on the wire, pulling down the hook of the balance, giving the centrifugal force in grams. The speed is read simultaneously with the balance.

The apparatus is now stopped and the mass slid out by hand till the balance reading is duplicated. The radius from the axis of rotation to centre of sliding mass is then measured.

Putting the mass, velocity and radius into the centrifugal force formula, the force can be calculated. This force is then compared with the actual force, observed with spring balance.

While crude, the apparatus works nicely.

Prof. Webster:—

A small hot air engine was shown with an indicator attached. The apparatus was so arranged that the indicator diagram could be seen on a screen while the engine was running. A lantern was used for this purpose.

Prof. A. G. Webster, Clark University, Worcester, Mass., then addressed the Association on,

The Gyroscope, How It Works, and What It is Used For.

Prof. Webster:—

Prof. Webster held the close attention of the Association during the whole of his address. Numerous experiments by way of illustration, together with lantern slides, added much to the interest. Various tops, symmetrical and unsymmetrical, were spun, leading up to the gyroscope and its application.

The simple gyroscope consists of a fly wheel, so mounted on a system of bearings that the axis may be tilted in any direction. When such a fly wheel is rotating in a given plane it resists any effort to change its plane of rotation by tilting the axis on which it is turning. If the gyroscope is rotating in a horizontal plane and an attempt is made to pull the axis to the left, a precession of the axis takes place to the right. The greater the pull the greater is the precession. After experiments illustrating the principle, Prof. Webster proceeded to show practical applications. The Griffin mill was first mentioned, slides being shown in this connection. A second application, he said, was to prevent seasickness,

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or, in other words, to prevent the roll of a ship at sea. A graph, representing the motion of the same boat with the gyroscope running and with it still, showed very clearly the controlling effect of the machine. A box was afterwards floated in a tank of water. This was more stable with the gyroscope running. While it may be feasible for boats of moderate size, for a great ocean liner the gyroscope would have to be so large and run at such an enormous speed that it seems impracticable.

Another use of the gyroscope is its application to the steering of a torpedo. The axis of the gyroscope is aimed at the mark and if the torpedo attempts to change the axis by changing its course, the gyroscope reacts upon a delicate steering device, which holds the torpedo in its true course.

The fourth application mentioned was the mono rail car. A model, loaned by the Central Scientific Co. of Chicago, was shown and operated before the Association. Two gyroscopes are so arranged that they work together to maintain perfect equilibrium of the car. The car is kept in equilibrium under all conditions by the resistance of the gyroscope to all influences which tend to change the position of its axis of rotation. It has already been shown that the mono rail car could be used for commercial purposes, but its general introduction would require such radical changes that it seems improbable.

The Association wishes through this report to express thanks to Mr. A. D. Handy for the use of a stereopticon equipped with a Nernst lamp which was very still in operation on the alternating current circuit; also to the Central Scientific Co. for the loan of the model Brenner car.

After a very profitable session the fifty-fifth meeting adjourned.

FRED H. COWAN, Secretary.

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Report of the Fifty-Sixth Meeting
OF THE
Eastern Association of Physics Teachers

SATURDAY, MAY 21, 1910.
PROVIDENCE, RHODE ISLAND

MORNING SESSION:
At Technical High School, Pond Street.

10:15 *A. M.*
Meeting of the Executive Committee.

10:30 *A. M.*
Business Meeting.
Reports of Standing Committees.
Committee on New Apparatus.
CLARENCE M. HALL, *Chairman.*
Committee on Magazine Literature.
EVANS WEBSTER, *Chairman.*
Committee on Current Events in Physics.
ROGER C. CHITTENDEN, *Chairman.*
Election of New Members.
New Business.

11:15 *A. M.*
Address: *Physics as a Part of the Grade Teacher's Equipment.* MR. JOHN L. ALGER, Principal of the Rhode Island State Normal School.

11:45 *A. M.*
Discussion.

12:00 *M.*
Inspection of the Laboratories.

12:30 *P. M.*
Luncheon *a la carte* at Mumford's Restaurant, 110 Westminster Street.

AFTERNOON SESSION:
At Wilson Hall, Brown University.

2:00 *P. M.*
Address: *Interferometry and a New Interferometer.* CARL BARUS, Ph. D., Professor of Physics, Brown University.

2:45 *P. M.*
Unfinished Business.

3:00 *P. M.*
Visit to Science and Engineering Laboratories.

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Proceedings of the Meeting of E. A. P. T.

Morning Session at Technical High School.

May 21, 1910.

The meeting was called to order by the president, Mr. Frank M. Greenlaw. The secretary read the list of standing committees for the coming year, as follows: New Apparatus, Clarence M. Hall, chairman, Homer LeSourde, E. W. Desper, C. H. Andrews, ex-officio; Magazine Literature, Frederick E. Sears, chairman, Francis R. Hathaway, Leonard J. Manning; Current Events, Roger C. Chittenden, chairman, Francis E. Mason, Fred H. Hadlock; College Entrance Requirements, A. B. Kimball, chairman, Calvin H. Andrews, Paul E. Sabine, C. S. Griswold, ex-officio; Committee on Relations with Other Organizations, J. C. Packard, chairman, C. H. Andrews, George A. Cowen; Committee to Investigate the Teaching of Physics in Small High Schools, John W. Hutchins, chairman, Calvin H. Andrews, N. Henry Black, Clement C. Hyde, Frank A. Waterman; Committee on New Books, W. F. Rice, chairman, W. D. Jackson, Charles E. Dickerson.

The printed report was accepted.

Report of Committees.

Report of the Committee on New Apparatus, Clarence M. Hall, chairman, was presented by Messrs. George A. Cowen, C. H. Andrews, and C. M. Hall.

Mr. Cowen:—

New Falling Body Apparatus.

This piece of apparatus is designed to find the value of the earth's attraction.

A metal plate suspended by a wooden rod about a meter long swings so as to meet a ball that started falling at the same instant. The distance the ball falls and the length of the rod supporting the metal table can be varied.

The ball is allowed to fall with the table at rest. A spot is made by the ball upon a piece of paper covered by carbon paper and held in place on the metal table. The ball is then allowed to fall with the table in motion. If the adjustment is correct the ball will strike the same spot.

The time of vibration of the metal table can be found by counting for five minutes, or by a comparison pendulum that swings beside it.

The metal table makes one-half a vibration before it meets the ball. The time of a whole swing is equal to $\sqrt{\frac{L}{1}}$. The time that elapses before the table and ball meet is 1-2 $\sqrt{\frac{L}{1}}$, whence $t^2 = \frac{L}{41}$. Substituting the formula $S = \frac{gt^2}{2}$, $g = \frac{8l.S}{1}$. S equals

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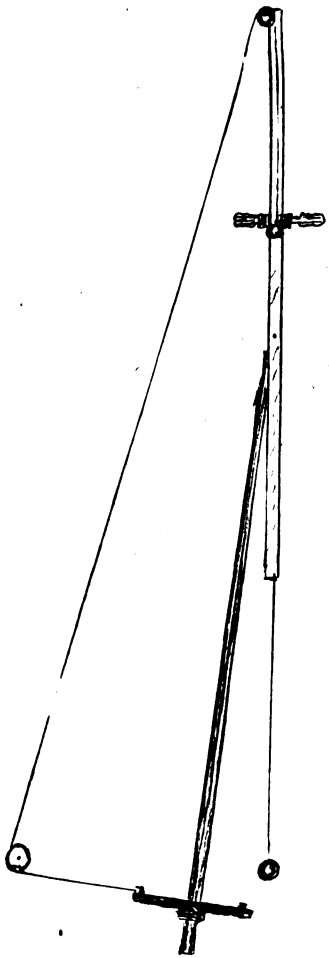
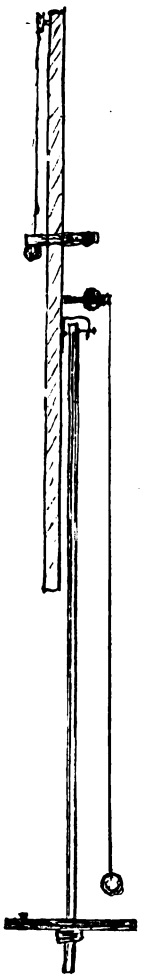
the distance of fall, L the length of the seconds pendulum, and 1 the length of the comparison pendulum.

The actual trial is as follows: S = 121 cm., 1 = 98.1 cm., L = 99.3 cm., g = 979.9.

As all the measurements are of such a nature that one is certain of the result to one millimeter, a very accurate value for g can be obtained.

Directions suitable for secondary school pupils are given below.





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New Falling Body Apparatus.

Purpose of the experiment, to find the value of G. Procedure:

With the swinging table at rest allow the ball to fall upon carbon paper, by burning off the thread just above the clamp.

Join the ball and table by a thread passing over the two pulleys and holding the table about ten centimeters from its original position.

Burn off the thread at the same place as before, just above the clamp.

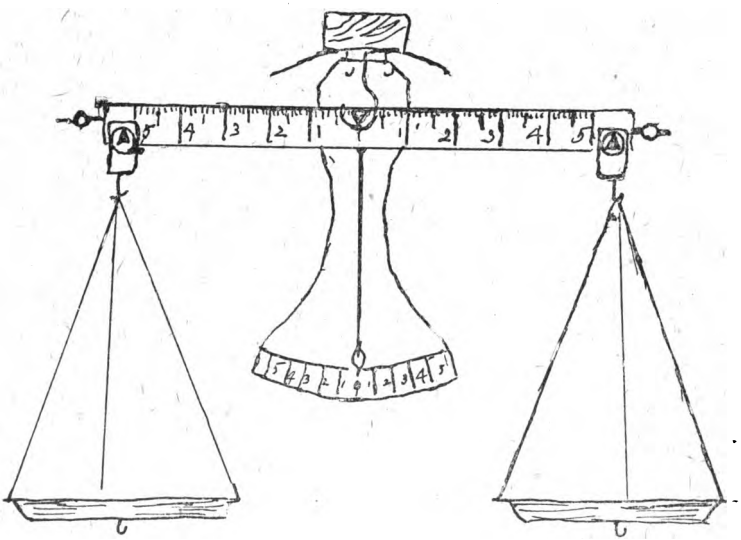
If the ball does not fall in the same place as when the table was at rest, raise or lower the clamp a few millimeters, as the case may require.

Make the comparison pendulum of such a length that it keeps time with the swinging table, and measure its length in centimeters. Computation:

Time of fall $= 1\text{-}2\sqrt{\frac{L}{1}}$.

From the formula $S = \frac{gt^2}{2}$, after substituting the value of t^2 find the value of G.

A Wooden Beam Balance.



The arms of the balance are about seven inches long. The whole is supported upon a knife edge and there is a like support for each pan. A six-inch pointer extending from beneath the beam makes careful readings easy. The beam is graduated in tenths of grams, up to five grams. By a change of rider weight in

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ounces can be obtained. There are hooks under the pans to be used in specific gravity work. There are adjusting screws on each arm. The balance can be put on the market for less than two dollars. It gives weights correct to tenths of a gram or hundredths of an ounce. The next decimal place can be estimated. It can be quickly removed from its support and put in a drawer. The method of very accurate weighing can be taught with this balance.

Below is a record of actual work done with this piece of apparatus. The substances used were cubic centimeters of different metals and alloys. Notice the weights obtained by a more expensive balance listed at $25.00.

	Table	Mr. Murphy	Miss Perkins	Miss Adams	Mr. Cowen
Mg	1.75	1.78	1.75	1.727	1.72
Al	2.67	2.71	2.70	2.677	2.69
Zn	7.20	7.19	7.19	7.137	7.14
Sn	7.29	7.30	7.30	7.255	7.27
Fe	7.80	7.80	7.80	7.750	7.78
Ni	8.57	8.78	8.80	8.746	8.76
Cu	8.90	8.90	8.90	8.855	8.88
Ag	10.57	10.51	10.43	10.431	10.47
Pb	11.35	11.31	11.30	11.277	11.30
A. B.		8.44	8.43	8.344	8.38
Brass	8.44	8.50	8.45	8.423	8.44
Bronze	8.70	7.71	7.70	7.667	7.69
		New Balance		$25.00 Balance	New Balance

Mr. Andrews:—

Universal Laboratory Weights—(new form).

(Made by C. H. Stoelting Co., Chicago. Price $2.75 per set.)

These weights are supplied with hooks and suspension staples so that they can be used in those experiments in which suspended weights are necessary—such as the experiments of the levers, pulleys, center of gravity, etc. The set consists of ten weights ranging from 1000 grams to 5 grams, with duplicates of the 200 gram and 20 gram weights. A careful determination of the value of the weights by comparing them with a standard set of the best gold plated weights gave a mean variation of the several weights from the true value of seven hundredths of one per cent. This accuracy fully equals that of the brass weights commonly employed in physical laboratories, and is sufficient to admit of their being used in connection with the Harvard Trip Scale.

The weights are neatly arranged in a nicely finished hard wood block.

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The Gaertner High School Galvanometer.

(Made by the Wiliam Gaertner Co., Chicago. Price, $2.50.)

This galvanometer is of the D'Arsonval type with phosphor bronze suspension, torsion head and inclined scale.

Its general appearance and finish is excellent—much better than what would be expected for the extremely low price. Its sensitiveness is sufficient for all experiments of the ordinary high school course in Physics. With a slide meter bridge, as used under ordinary conditions a variation of one-half of a millimeter in the position of the slide is readily noted.

This galvanometer will make it possible for the high schools of limited means to equip their laboratories for individual laboratory work in electricty.

Dynamo Analysis Apparatus.

(Wm. Gaertner & Co., Chicago.)

This apparatus consists of a coil of wire mounted between the poles of six powerful permanent magnets. The terminals of the coil are connected to ring collectors which make contact with brushes. The coil is actuated by a spring with a release which allows the coil to move through an angle of ten degrees at each release of a ratchet. If the coil is connected to a galvanomter the strength of the induced electromotive force may be noted throughout a complete rotation of the coil.

Mr. Hall:—

The first piece was a Rumford photometer with the screen made translucent, so that the shadows of the post formed by the two lights could be viewed from the back. The photometer can be pointed at the lights, and the eye kept from direct light of the lamps. The whole apparatus is made by pupils from an ordinary shoe box, the oiled paper screen being made by dropping candle wax on plain white paper. It is used in the elementary science work in measuring the candle power of home lamps, by comparison with a paraffine candle.

The second piece was a Bunsen photometer, made of a pasteboard mailing tube, in which were placed two mirrors and a screen with grease spot, which could be viewed from outside the tube through two holes cut the pupil distance apart, so that the eyes looked down into the two mirrors, and saw the image of the grease spot on both sides. The optical bench is a meter stick mounted on wood supports and the supports each carry a porcelain lamp socket, in one of which is placed a standard incandescent lamp and in the other the lamp to be tested. The device shows a difference in the appearance of the grease spot, with a motion of one centimeter of the photometer tube. It is easily made by pupils.

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This same support with lamp socket is used in exercises on images formed by lenses, by covering the lamp with a metal hood containing a hole crossed by a grating, which comes at the height of the center of the lens.

The ordinary lens holder, screen holder, made of metal, are used and slide on the meter stick used as an optical bench.

By using the electric lamps one avoids the flicker, odor, and varying candle power of the candle or kerosene lamp flames.

Reports of other standing committees were not given, owing to unavoidable delay in appointment of committees and absence of chairmen.

New Business:—

Mr. George A. Cowen stated that he had communicated with the president of the Science Department of the N. E. A., offering the assistance of the E. A.P.T. in any way that should be desired, and asked for approval by the Association. It was voted to approve.

The address, "Physics As a Part of the Grade Teacher's Equipment," was then given by Mr. John L. Alger, Principal of Rhode Island State Normal School.

Mr. Alger:—

When so many demands are being made on the modern curriculum, and so many complaints that far too much is already expected of teachers and students. It is not possible that more requirements can be given without very definite readjustment of present courses and methods.

As teachers, we are all looking for the wisest and most practical results in our courses and methods for all schools and under all conditions. As teachers of a particular branch of study you are helping to find the exact standing of your chosen subject in this broad field, and to see that it gets the position it so richly deserves.

We must realize that education does not always mean education in the public schools or education in large masses. The problem of determining the ideal education, for the ideal child, with ideal conditions of health, and wealth, is also one that should be seriously discussed. In fact, teachers of physics are particularly concerned in this last problem, for this subject will play a large part in the education of such a child. If we could do as we would with the education of a child we should certainly let him use and investigate the common things around him. He would be given tools and materials so that he might use his hands as well as his brain. We should let him master the simple elements of physics, and go as much farther in the subject as his tastes and individuality seemed to warrant. One father of a twelve-year-old boy

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recently stated that he had already spent nearly $1000 on the boy's experiments in electricity, and that he was going to give him the best education that could be had in this subject. The best of it is that the boy's progress has seemed to justify this expense. We have plenty of modern instances to show that such education is worth while in many cases, and that young boys may be masters in many different lines of knowledge. Are we on the eve of great discoveries in the science of education, or are we just learning to make use of the discoveries of long ago? Without doubt we may expect great things in the near future in all education, perhaps especially in the education of those favored individuals whose training can be made the best possible, regardless of expense, in time, and patience, and enthusiasm, as well as in mere money. It seems to be true also that the real and the practical are to enter rapidly into all our systems of training, and of all the practical subjects that enter into our grammar schools, it is evident that physics must rank with the highest. This is true because it is of unusual interest to the children at that inquiring and investigating stage in the child's growth, and because it concerns so many of the exceedingly practical matters of every day life. We shall find a multitude of questions that can be answered by physics, especially if we include in this subject the simple elements of mechanics. Such experiments as those for determining the strength of strips of wood, or of pieces of wire, or for testing levers to determine the practical importance of their different forms, or experiments with pulleys, or with the simple laws of motion, are better adapted to the grammar school age than to the age of students in their last year in the high school, for manifest reasons.

There are also endless ways in which the physics and the arithmetic could be brought to aid each other in stimulating interest, and in furnishing a real need for employing the processes learned or to be learned.

Physics and manual training furnish an unusually fine combination. In the manual training we are at present looking for something practical to do with our tools and our facilities. We no longer want the mere type forms as evidences of our skill. If a boy can make a scientific toy, or a bit of apparatus that will answer for his experiments, or if he can make a telegraph instrument, or almost anything connected with electricity, he will be delighted with the opportunity.

The failure to make a real success of physics teaching in the grammar schools up to the present time has been due largely to causes that we may easily ascertain.

It has been attempted on the same formal plan that has been so long used in the high schools. The children have been given definite experiments to perform. Their books or their teachers

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have outlined exactly what they are to do. The apparatus has been provided, and a definite time set for the task, and it has been performed as a task. If we really wish to stimulate an interest in this subject, this formal way of getting at it is about the worst that could be employed.

We should instead have great freedom as to what experiments are to be employed, and the order in which they are to be taken up. Different members of the class should take different experiments. Children should be given a question or a suggestion, rather than a fixed statement of all that they are to do. They will invent ways of doing things, and will welcome suggestions of other possible ways if these are given at just the right time and in the right way.

If this is possible under ideal conditions, at least something of it is possible in every school, provided the teacher is well trained for the work. If teachers are trained along literary lines to too great an extent, it will follow that in most cases the attempt will be to make the children reach literary standards, while for the majority of children the proper training must be along intensely practical lines.

It is clear that most valuable training, in broad and general culture as well as in preparation for living, may be secured without the mastery of a single foreign language. The argument for the real and practical is not a bread and butter argument. It is not an effort for the gaining of more fortunes. If it succeeds in bringing more happiness into the lives of our pupils few would be so hardy as to say that this is not more eagerly to be sought than any abstract or theoretical culture. There has already been too much education at the expense of health and happiness. One does not need to get so far away from the humanities that he can no longer commit to memory or enjoy choice poetry, but it is easily possible that a scientist, immersed in his researches, may secure as much enjoyment from his life, and accomplish as much for the good of humanity, as those who may have a finer literary appreciation and a greater ability along the more distinctly cultural lines. We have been trying to fit all our students for the literary side of culture, neglecting the tastes that must and that should l'e along quite different lines, while it may be found true that by far the larger proportion of our children not only would not, but perhaps could not if they would, become truly educated along any other than the so called practical lines.

We seem to be approaching a time of general readjustment, now that the theories of formal discipline are being so vigorously attacked. Whatever may be the outcome of the present conflict, it is evident that a very considerable change is to take place, not so much in regard to subjects taught as in regard to the methods of

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teaching these subjects. We have heard much concerning the value or want of value of Latin and Greek. It seems to me that physics and chemistry, as they are ordinarily taught are in a fair way to be classed with the useless and the outgrown in our modern reconstruction, whenever this comes. If they do not touch life very closely—to use the common expression for that which is most desirable in our education—they are no longer of value. Text-book work, formal and fixed lists of experiments to be performed in a definite order, are as formal and of as little value, as any delving for Greek roots. Indeed they are much less interesting and very much less educational. If science is to take its proper place in a suitable curriculum it must be freed from the stilted form in which it is too often presented.

Much of this important subject should be mastered while the child is yet a child, leaving the more abstruse problems for the last years in the high school, or for the careful investigating of the college or technical school. It is seldom that a student can gain a love for mathematics or for physics after he reaches college. If he has not gotten a fair start and some ability in these directions as a child he will receive little value from studying the subjects later.

A wiser course, wherever conditions will allow, would be to start each student on a line of investigation that will really interest him and lead him on so that he will begin to find out things, and to hunt through his text-book and his reference book for facts that he may use. He should early learn to keep an exact record of what he does, in a thoroughly scientific manner, and he should be able before he has finished an investigation to explain what he has done, fully and clearly.

If his study of Latin is to be tested by his ability to read and explain at sight, much more should his work in physics be judged by his ability to show that he has really gotten into the spirit of investigation. You will agree with me that one good experiment, worked out with originality, and with a real desire to find out why and how the thing is so, is worth any number of experiments performed by rote, in a perfunctory manner—often with a printed statement before the student of just what he is to do, and most of what he is to say. Physics taught in any such manner is dry and useless stuff. There is no science and no pedagogy in much of the physics teaching, and I believe that the subject can never be well taught until we can get away from any formal list of experiments, especially from those that have full printed statements of just what is to be done and what results are to be expected.

The order in which the experiments are to come is also exceedingly important. The beginning should be made the most interesting part of the whole course, and to the student most val-

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uable results should come from his first experiments. As interest in geometry may be killed at the beginning of the course by the introduction of propositions that seem to the student to be absurdly simple, so interest in physics will suffer from any wrong notion of the subject that the student receives from his first contact with it. One of the most widely known and successful teachers of botany in our American colleges says that he begins his work in botany with the use of the compound microscope in order to let the student feel that he is gaining something of importance and interest. It is only after the class is well started and has learned what it wants to do, that they go back to the simple microscope and begin to get at the necessary elements. So the experiments in physics must come at a time and in an order dependent on the need in each case.

What we should have is not more text-books or more definite lists of experiments, but a greatly increased list of suggestions as to ways in which students may be led into this great subject. The parallelogram of forces is intensely interesting when a need to know its results has been developed, not otherwise. Experiments conducted without other interest than that of getting them done and of completing so much of the course, will be carried out in a slipshod way, without any real confidence or faith in their results; but on the other hand, a good part of the value of the subject from any cultural point of view lies in the confidence that may be established in the learner's mind in the results of his own experiments.

Most colleges seem to be ready to welcome such variations as I have indicated in the fixed course of study; to recognize real ability wherever it is met; and to make exceptions for students who have been well trained, even if the preparation is different from that laid down in their catalogues. With few exceptions, the colleges are no longer trying to dominate the high schools, but are honestly looking for the best product that can be turned out, regardless of just how it may be produced. The task before you, as teachers of physics, is not how best to follow a fixed course, but how to get the finest results with all your students.

Here is where much work must be done in laying plans, in enlisting the co-operation of the teachers of manual training, in showing the possibilities with indivdual cases and with whole classes, in outlining long lists of suggested lines of experiments, as well as in training teachers who shall be competent to handle the subject in the grades and in private schools. It is here that we find our greatest occasion to regret that there are not more men who are teaching small children, for as a class they are apt to have more of an aptitude for the mechanical side of training.

It will also be a work of years of training in elementary schools and in high schools before we can send out teachers who

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are really fitted with a broad working knowledge of the possibilities of this subject. This cannot be done in the normal schools and colleges alone. It seems to me that the next step will be along the line of better work in the high schools, and more general experimentation by individual students in private schools and at their homes, in this way bringing the possibilities of the science as a part of the education of children more fully to the attention of the public.

I am aware that many books on physics for the grammar grades have been written, with most of which I am not familiar. Such books as a rule, so far as I have been able to judge, seem to tend towards frightening away the student or the teacher by their very fullness of description, or by the amount of material needed for the experiments.

As to the experiments that may be performed, well trained and appreciative teachers may easily interest children in the velocity of sound. Cameras, lenses, mirrors, prisms, spectra, etc., will furnish material for much that will prove of value. Pumps, engines, motors; levers, wheel and axle, pulley, wedge, screw; barometer and thermometer; influence of color; principles of heating and ventilating; expansion and contraction by heat, temperature of salt and ice; pitch, difference in sound of the engine's whistle as it goes by us, siren, phonograph; magnetism, batteries, telegraph and telephone—these and many other simple and common things and phenomena will prove of the most vital interest and value if they can only be presented in the right way.

We should soon be confronted by the fact that any good work in physics means much skill in mathematics, and this is one of the very things that we want to have happen. Such a stimulus is exactly what we must have if we are to secure the mastery of that subject.

As we learn more about the difficult task of teaching children to study, we are coming more and more to face the fact that we must have, not pages of explanations to be committed to memory, but definite problems of all sorts that are to be solved by the children, and of all the practical problems that may be considered, there are few that will outrank those of physics in interest, and in giving a real insight into the things with which we have constantly to do.

If the children need the subject, it stands to reason that the teachers must have more of it; and if it is of value in the training of children, it will be found of value in the preparation of those who are to guide and instruct the children.

The chief difficulties in the way at present are the lack of time and the lack of preparation in the elements of the subject, as well as in a too general feeling that the subject is not important. We

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shall, however, look for a better appreciation of physics as a most practical and helpful part of the education of most children, especially of those who are obliged to leave before entering the high school.

The greatest element of hopefulness lies in the manual training situation. The two subjects can be made most helpful to each other, and I believe that we shall soon see them permanently united.

At the close of the address the discussion was taken up by Mr. C. E. Fisher, Mr. John W. Hutchins, and Mr. C. H. Andrews. One of the points made by Mr. Fisher was that plans for new courses should be announced far enough in advance so that teachers might be properly fitted to teach them, and that the failure of many courses could be traced to lack of time for adequate preparation of the teacher. Mr. Hutchins stated that poor results of Science teaching were partially due to the crowded conditions of classes; that with thirty-eight pupils to a class the teacher can spend but little time in following up lines of work specially interesting and valuable to individual pupils. He also suggested that Science teaching in high schools would be greatly benefited if efficient teaching of elementary science could be introduced into eighth and ninth grades.

Mr. Andrews spoke of work attempted in Worcester schools in connection with manual training a few years ago.

At the close of the discussion a vote of thanks was given to Mr. John L. Alger for his interesting address. Adjourned.

Afternoon Session at Wilson's Hall, Brown University.

President Greenlaw called the meeting to order, and introduced Prof. Carl Barus.

Prof. Barus first showed a device for compounding wave motion, showing reinforcement, interference, stationary waves, beats, etc. A good description of the machine and its applications may be found in "Science," issue of Mar. 17, 1899. Then Prof. Barus gave an interesting address on Interferometry and a New Interferometer.

Mr. Barus:—

Interferometry and a New Interferometer.

1. Thin plates.—The Speaker began with the interferences of thin films subject to the equation

$$2 e \mu \cos r = n \lambda \quad . \quad . \quad . \quad A$$

for dark bands, where e is the thickness of the film of refractive index μ, r the angle of refraction for an incidence i ($\sin i = \mu \sin r$), λ the wave-length observed, and n a whole or distributive number.

The first case (chart shown) would be that of varying n with r

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alone, and would necessarily result in a series of rings symmetrical about the normal to the film from the eye of the observer. In a second case, n may vary with e alone, the film being wedge-shaped. Neither of these has much relevant interest; the former will be referred to in case of Herschel's fringes below.

2. Normal incidence.—If, however, the mirror, or lower face of the film, is movable parallel to the upper, on a micrometer screw, and if the incidence is normal (diagram shown), the equation takes the simple form ($\cos r = 1$)

$$2 e \mu = n \lambda$$

or for air, $\mu = 1$,

$$\delta e = de / dn = \lambda / 2,$$

where δe is the displacement of the mirror for one reappearance of the same aspect of the ring-shaped figure.

If the upper mirrors are partially silvered, so that as much light is transmitted as is reflected, this adjustment gives us Fabry and Perot's interferometer, admitting of the expression of any small micrometer length δe in terms of the wave-length of light. Small lengths δe are in question so that this method is limited in its scope, however accurate, and the optical surfaces must be perfect. A monochromatic source of light like the mercury lamp is presupposed.

At this point a pair of Brashear's optical flats were shown, together with the apparatus for Herschel's fringes, in which relatively large air-space is admissible under conditions of large r, since in equation A, e, and the cosine of r compensate each other.

3. Wave machine.—The speaker then made a digression bearing on interference in general. A special type of wave-machine was brought forward, admitting of the composition of harmonic curves, and of the corresponding progressive waves. The machine compounded beating waves, either for differences of wave velocity (polarization) or differences of wave-length (as in acoustics), and stationary waves, either with fixed or with variable nodes. Waves with components, either coplanar or normal to each other, of the same or of different period, came within the scope of the machine.

The lantern demonstration of interferences corresponding to Young's experiment and the properties of such fringes were illustrated by duplicate slides, moving parallel to each other. Finally a variety of other optical apparatus, more or less imperfectly adapted for interferometry (Fresnel mirror, Billet lens) was exhibited.

4. Color—The occurrence of a bewildering array of compound colors when white light is used was next discussed (diagram shown). According to equation A

$$n = (2 \mu \cos r) \frac{e}{\lambda},$$

or the successive extinctions ($n = 1, 2, 3$, etc.) when r is constant

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occur at intervals directly as the film-thickness e and inversely as the wave-length. Hence if two lines are drawn in a graph in which n is mapped out in terms of e, the one for red light must have about half the slope of the one for violet light, the other colors falling in between. From such a diagram most of the color problems connected with white light may be read off at once. Thus plates must be thin relative to λ, or the light rejected will be the same as that retained, whereupon both will be white; the number of fringes crowded into the limits of the spectrum varies as e; fringes vanish first with white light, finally with approximately monochromatic light, etc., the detailed character of which may be estimated quantitatively.

5. Interferometers.—With this introduction the new type of interferometers, beginning with Jamin's, were taken up, in which the rays are in marked degree separable in position and direction. In all these cases the phenomenon of equation A is duplicated, as it were. Thus in Jamin's apparatus with two parallel plates of thickness e and e′ equation 1 becomes

$$2\,e\,\mu\cos r = n'\lambda \qquad\qquad 2\,e'\mu\cos r = n''\lambda$$

or

$$2\,(e - e')\,\mu\cos r = n\lambda$$

Thus it is merely the difference of thickness that is in question, and the plates may be at any distanc apart (chart shown).

In Jamin's case the two rays, however long, are still in parallel and not very far apart. Michelson (chart and apparatus shown) carried this separation forward to an almost ideal degree of perfection, by not merely separating the rays of any length which eventually interfere, but by leading them at right angles to each other. If the reflection of one of the two mirrors at right angles to each other in the inclined plate be considered, it will be seen that the case is identical with equation A, and that $r = 0$, $\mu = 1$. Thus $2e = n\lambda$ and

$$\delta e = de \,/\, dn = \frac{\lambda}{2}$$

is the difference of optical path which corresponds to the reappearance of the same type of ring-shaped pattern.

6. Metrology.—The simplicity of the last equation makes this apparatus peculiarly adapted for metrology, where the purpose is to express the standard of length in terms of the wave-length of light. One may notice that both mirrors may be moved, or one assisted by a compensator, and as the interference depends merely on the difference of distance from the inclined plate, any length of standard may be stepped off in terms of the wave-length chosen.

Indices of refraction of laminae are determinable by passing one of the separated rays through them.

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7. Ether drift.—Theoretically, the most important application is the determination of the presence or absence of ether drift. The earth's velocity in its orbit is small as compared with the velocity of light; but the ratio nevertheless falls within the scope of interferometry by this apparatus. If the ether is stationary, as the theory most approved at the present day, that of Lorentz, assumes, then the drift of light waves on moving earth must be observable. To the discomforture of cotemporaneous electro-magnetics, Michelson and Morley found no drift whatever. A dilemma, or rather, a burning question in modern physics thus presents itself, as to what may be done with the ether. It is inevitable as a receptacle of energy in the interstellar spaces.

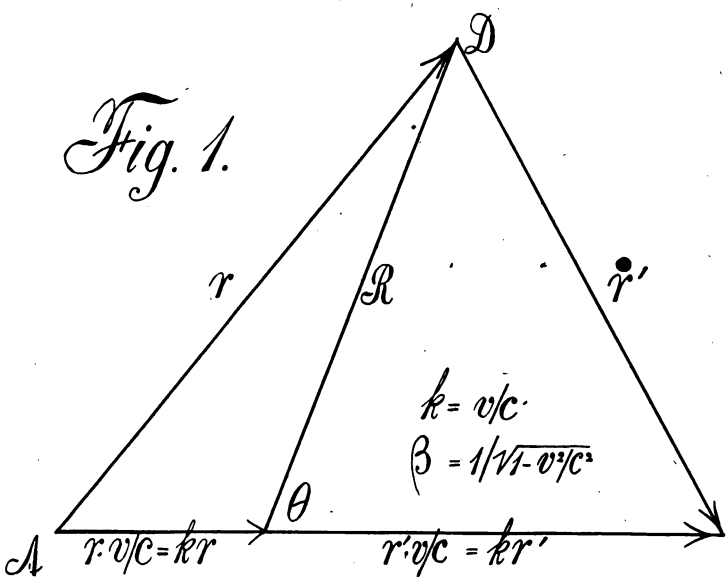

Fig. 1.

The speaker indicated the conditions (Fig. 1) involved, as follows: Given a fixed ether and an earth drifting with velocity v; then while a ray passes over the distance r, the earth will have moved over a distance $(r/c)\ v = k\ r$, say, where k is very small. Hence the path R is given in terms of the path R corresponding to a stationary earth by

$$r = \sqrt{R^2 + k^2 r^2 + 2Rkr\cos\theta} = R\sqrt{1 + k^2 + 2k\cos\theta}, \text{ nearly.}$$

Similarly the return path would be

$$r' = R\sqrt{1 + k^2 - 2k\cos\theta}$$

Expanding by the binomial theorem, and dropping terms above the third power of k

$$r = R\,(1 - k\cos\theta - k^2/2 + 3/2\,k^2\cos^2\theta)$$

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In Michelson's apparatus the two rays are at right angles to each other. Let one be in the direction of the earth's motion, v, so that $\theta = 0°$ and $180°$, the other ray normal to v so that $\theta = 90°$ and $270°$. Hence in the line of the earth's motion the optical path outgoing and incoming would be

$$R\ (1 - k + k^2)\ + R\ (1 + k + k^2) = 2\ R(1 + k^2)$$

Normal to the line of the earth's motion the optical paths are

$$R\ (1 - k^2/2) + R\ (1 - k^2/2) = 2\ R\ (1 - k^2/2)$$

and thus the path differences are $R\,k^2$.

If the instrument is rotated 90°, so that the conditions are reversed, the path difference is doubled and becomes $2\,RK^2 = 2\,Rv^2/c^2$. This path difference means $2\ Rk^2/(\lambda/2)$ or $4\ Rk^2/\lambda$ fringes passing any point, a number which should be measurable; but no effect was found.

To bridge over the dilemma, Lorentz and Fitzgerald suggested that all dimensions may be shortened in the direction of the earth's motion by $\sqrt{1 - k^2}\ /1$, or nearly $1 - k^2/2$. In such a case the path parallel to the earth's motion would be

$$2\,R\ (1 - k^2/2)\ (1 + k^2) = 2\,R\ (1 + k^2/2), \text{ nearly,}$$

the same as the normal path.

8. Principle of relativity.—The search for a more systematic explanation was most successfully met by the famous hypothesis of relativity, chiefly due to Einstein. It is equivalent to postulating four dimensions for space (Minkowski) so that the linear space element becomes

$$ds^2 = dx^2 + dy^2 + dz^2 - d\,t^2$$

if the velocity of light is taken as unity.

To resume the argument of Einstein, let two systems S at rest, and S' in motion in the direction x with a velocity v be given. The clocks of both systems are identical if at rest. S and S' are coincident at time $t = 0$. Then the position of the S' origin

$$x' = 0,\ y' = 0,\ z' = 0$$

seen from the S origin becomes

$$x = vt \qquad y = 0 \qquad z = 0$$

Hence

(1) $$x' = a'\ (x - vt);\ y' = b'\,y;\ z' = c'\,z$$

are the equations of transformation to specify the relations of S and S'.

But the velocity of light c measured in either system is to be always the same compatibly with experiment. Hence a given length in either system must be expressible by the same velocity c and the respective times t and t' as $r = ct$ and $r' = ct'$ or

(2) $$x^2 + y^2 + z^2 = c^2\,t^2 \text{ and } x'^2 + y'^2 + z'^2 = c^2\ t'^2$$

From this it follows eventually that if equations 1 and 2 are to be compatible, the position co-ordinates and time of the system S'

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when regarded from the system S must stand in the relation

$$
\begin{aligned}
t' &= \beta \quad (t - vx/c^2) \\
x' &= \beta \quad (x - vt) \\
y' &= y \\
z' &= z
\end{aligned}
\tag{3}
$$

where $\beta = 1/\sqrt{1 - v^2/c^2}$, the very ratio demanded above.

Thus if the distance apart of two points x'_1, y'_1, z'_1, and x'_2, y'_2, z'_2, in the S' system at a given time be regarded from the S system, equations 3 show, since $t = t'$ at any given instant

$$x_2 - x_1 = (x'_2 - x'_1)\sqrt{1 - v^2/c^2};$$
$$y_2 - y_1 = y'_2 - y'_1\ ;\ z_2 - z_1 = z'_2 - z'_1$$

or the x dimension is shortened in the ratio $\sqrt{1 - v^2/c^2}/1$, as demanded by the Michelson and Morley experiment.

9. Diffraction.—The speaker next considered the phenomenon of diffraction, exhibiting charts to indicate the meaning of the variation of the equation

$$\sin r - \sin \theta = \lambda / D \tag{B}$$

where θ is the angle of diffraction and D the grating space.

Replica gratings with free faces admirably made by Mr. Ives, with rulings covering as much as 3 in. by 2 1•2 in. were shown.

10. New interferometer.—The speaker then proceeded to explain the new interferometer, wherein a combination is made of both the phenomenon of interference and diffraction, or of the equations A and B, above. The instrument was at hand in various forms, and charts were provided to illustrate its action. This interferometer has certain advantages inasmuch as ordinary plate glass and replica gratings suffice its demands. The fringes are rigorously straight and not annular, as in the instruments above for like adjustment. Hence their distance apart and their inclination may be measured by ocular micrometry. Small lengths and small angles (a few seconds) are thus both made subject to micrometic measurement. There are two sets of fringes which may be adjusted so that about ten small fringes occupy the space of a large set, which is equivalent to a coarse and fine adjustment. This makes the instrument available for measuring sudden phenomena, like the expansions in magneto-striction. Finally white light suffices the purpose of the measurements, so that monochromatic sources are not necessary, and the spectrum line may be kept in focus for the given wave-length taken. In Fig. 2 *gg* shows the grating between plates of glass, *ff* acting as the mirror. The ray RD_2 RD_1 is regularly reflected when issuing at o. But to it belong the two diffracted rays t_1 and t_2. In regard to t_1, however, it might have come by diffraction only from D_1, or by diffraction first and then reflection at *ff* from DR_1, so that three incident rays DR_1

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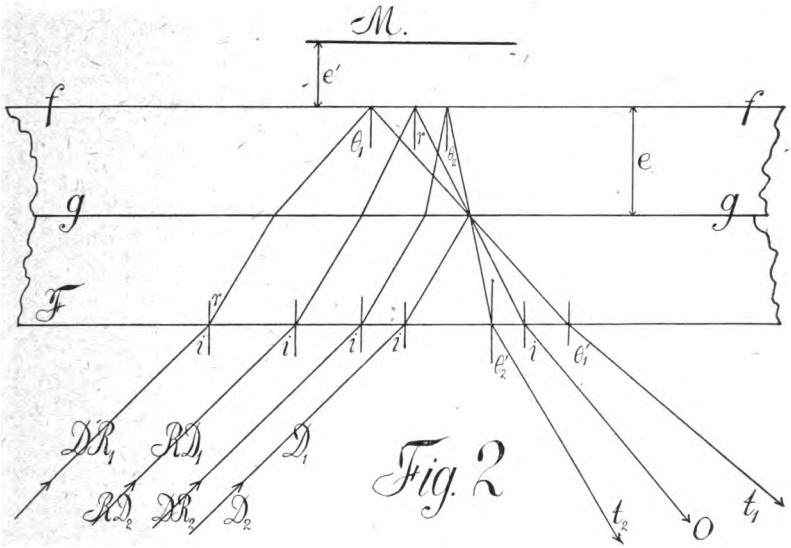

Fig. 2

RD_2 and D_1 pass along t_1. The same is true for t_2, so that there are two triplicate groups of interfering rays. To each of these groups t_1 and t_2, there are, therefore, three interferences, DR_1 and D (small), RD_1 and D' (small), DR_1 and RD_1 (large). The former two merge into one and constitute the fine adjustment on the latter (coarse) adjustment, giving rise to the peculiar fluted fringes characteristic of this apparatus. In practice the glass plate *ffgg* is removed and the silver mirror M substituted.

11. Equations.—The distance apart of the fringes increases as e decreases, but the law is naturally complicated and must be omitted here. The relative size of large and small fringes may be varied and e may be increased to about 1 cm.

The interferometer equations are relatively simple. Per fringe the displacements δe of the mirror would be respectively

$\delta e_1 = \lambda / 2 \cos i \qquad \delta e_2 = \lambda / 2 \cos \theta \qquad \delta e_3 = \lambda / 2 (\cos \theta - \cos i)$

in the three cases, where i is the angle of incidence, θ the angle of diffraction in air. Sensitiveness increases with the angle i but the limit is already nearly reached at 45°. It furthermore increases with the grating space D, but the limit is again nearly reached at 10,000 or 15,000 lines to the inch.

The fringes (small and large) may travel in the same or in opposite directions as e increases. The velocity of the large fringes may be zero and the rate of motion of the small ones be unequal in a way to introduce singularly beautiful phenomena. The limiting

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sensitiveness in all cases is $\lambda/2$. Finally δe increases with wave- length, but not proportional to it. The fringes may lie at infinity, or in any other focal plane, dependent upon the wedge of air inclosed. If parallel rays fall on the slit small angles are measurable to a few cm. of arc.

12. Applications.—An application to magneto-striction of soft iron (sudden expansion of length due to magnetization) showed a total length increment of 3×10^{-6} in a saturated field. About 1/100 of this could still be detected in low fields. The phenomenon terminates abruptly (The apparatus was shown).

The vibrations of the ear-drum may be imitated by using a round grating film without glass and suitably tracing the interferences when the film vibrates.

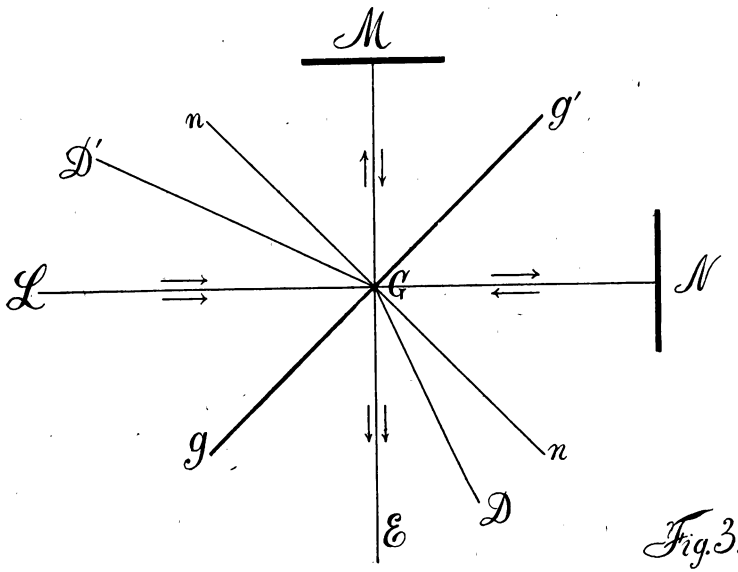

Fig. 3.

The speaker then referred to the further possibilities of this apparatus. Thus far the distances apart of mirror and grating are the thickness of air space under observation lay within 1 cm. But by adapting either Jamin's apparatus, in which the face of the second mirror is a grating, or Michelson's interferometer, in which the silver face of the oblique plate is a grating, the thickness e may be increased at pleasure.

To take the example of the Michelson type stripped of unnecessary details, let gGg' in the figure be the grating or ruled surface, n its normal, L the source of white light, M and M the mirrors, and E the eye. In the usual way the rays from L interfere at E.

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Now replace L by a slit and collinator, E by a telescope focused for parallel rays. The eye at E now sees a sharp line of light. At D and D', however, there must be two diffraction spectra coinciding in all their parts and hence interfering rhythmically if all adjustments are sufficiently perfected. The other two diffractions within MGg' and EGg are usually lost at an incidence of 45°.

The attempt to produce these interferences D, D', with replica gratings is liable to result in failure; for while the transmitted system NGD shows brilliant spectra, the reflected system MGE is dull and hazy. Both spectra are clearly in evidence and may be brought to overlap. The film, however, does not reflect in a degree adequate to the transmission. Attempts, however, are in progress to realize the condition of equality with a grating actually ruled on glass, or possibly with a modified film.

Brown University, Providence, R. I.

On motion by Mr. Miller, a rising vote of thanks was given Prof. Barus for his most entertaining and instructive address.

The meeting closed with inspection of the Laboratories.

RALPH CHANNELL, Secretary.

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PROGRAM OF

THE FIFTY-SEVENTH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, November 19, 1910

AFTERNOON MEETING.

At Jefferson Physical Laboratory, Cambridge.

1.30 P. M.

Meeting of Executive Committee.

2.00 P. M.

Address: "The Poulsen Arc and Its Application to Wireless Telephony." G. W. Pierce, Assistant Prof. of Physics, Harvard University.

Annual Address of Vice-President.

"Some Defects in Teaching," by Mr. C. S. Griswold of Groton School.

Business.

Report of Secretary.

Reports of Standing Committees.

On New Apparatus. Clarence M. Hall, Chairman.
It is expected that a representative will be present and demonstrate the Hemenway Oil Seal Pump.

On Magazine Literature. Frederick E. Sears, Chairman.

On Current Events in Physics. Roger C. Chittenden, Chairman.

On New Books. William F. Rice, Chairman.
Linebarger's, Gorton's, and other texts will be reviewed.

EVENING MEETING.

Saturday, November 19, at Boston City Club, 9 Beacon Street.

6.30 P. M.

Dinner.

After-Dinner Discussion: The Report of the Committee to Investigate the Teaching of Physics in Small High Schools. Dr. Kerschensteiner, Supt. of Schools, Munich; Hon. David Snedden, Commissioner of Education; William B. Orr and Charles A. Prosser, Deputy Commissioners; Prof. Paul H. Hanus, Harvard University, and J. W. MacDonald, Agent of State Board of Education.

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Proceedings of Fifty-Seventh Meeting of the Eastern Association of Physics Teachers, Nov. 19, 1910.

The afternoon session of the Eastern Association of Physics' Teachers was called to order by President Greenlaw at 2 p. m.

The President introduced Prof. G. W. Pierce who spoke on "The Poulsen Arc and Its Application to Wireless Telephony."

(Abstract (1) of an Address by Professor G. W. Pierce, of Harvard University.)

I have arranged to show some elementary experiments connected with wireless telegraphy and wireless telephony. By the aid of these experiments I hope to illustrate some of the more recent developments in this interesting field of research, and in particular to give some idea of the manner in which the human voice applied to an ordinary telephone transmitter may modify a train of electric waves, so that clear, distinct speech may be transmitted to a distance without intervening wires.

In beginning the account, I beg your indulgence while I review some of the fundamental facts about electric waves, and show and describe some of the apparatus used in wirless telegraphy. I do this because the wireless telephonic receiving appraratus is identical with that used in wireless telegraphy, and the transmitting apparatus of wireless telephony, is a development from the transmitting apparatus of wireless telegraphy.

It is no doubt familiar to you that the discharge of a condenser or Leyden jar, through a low-resistance inductance is oscillatory in character. This was mathematically predicted by Sir. William Thomson in 1853, and was proved experimentally by Dr. Feddersen at Leipzig in 1859 by means of revolving-mirror photographs of the spark of the condenser discharge.

[Lantern slides of the revolving-mirror apparatus (Fig. 3 P. W. T.(2)) and of several spark photographs (P. W. T., Fig. 4) were shown.]

The spark photographs show that each terminal of the spark is alternately bright and dark, clearly indicating the oscillatory

(1). Written by the speaker from memory sometime after the address, and therefore not in any way an exact verbal account.

(2). Since, on account of expense and lack of space, it does not seem advisable to reproduce all of the lantern slides used in the lecture, only a few will be given in this abstract. The others may be found in my **Principles of Wireless Telegraphy, 1910, McGraw-Hill Book Co., New York,** and are here designated by reference to the Figure number in the book, thus: (Fig ....P. W. T.)

References to the text of the book will be designated by page, together with the initials P. W. T.

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character of the discharge and affording an easy method of determining the period of oscillation from the period of revolution of the mirror. The period of one complete oscillation determined for some of the photographs is in the neighborhood of one one-millionth of a second. This is approximately the vibration period employed in wireless telegraphy and wireless telephony; but this period is made different for different stations and for the same station at different times, so that thereby the wave length emitted by the station may be varied for the purpose of avoiding interference.

Now it is to be noticed from the spark photograph that after a few oscillations (say ten) the discharge ceases. That is, with a single charging of the condenser or sending antenna the train of oscillations consists of a small number of oscillations (about *ten*, depending on the constants of the circuit) occupying altogether an interval of about ten one-millionths of a second. This produces a train of electric waves arriving at the receiving station and affecting the receiving station for this short interval of time; namely, for about ten one-millionths of a second. The effect then ceases. In producing a wireless telegraphic signal, the sending antenna is again charged, for example, from a step-up transformer, and discharges and produces a second train of waves. This second charging of the antenna in wireless telegraphy is usually produced about one two-hundredth or one five-hundredth of a second after the first; that is, after the lapse of a long time in comparison with the duration of the actual discharge. This process of charge and discharge is repeated. In consequence, there arrives at the receiving station these separate trains of oscillations with comparative long intervals between.

Let us now transfer our attention to the receiving station. Familiarity with the general character of the receiving apparatus is assumed, and only the manner of operation of the detector is here noted. The use of the old filings-coherer for wireless telegraphy has been discontinued, and, instead of the coherer, relay and sounder of ten years ago, detectors of the electrolytic type or of the crystal-contact type are now generally employed, and with these detectors, a *telephone receiver* even for wireless telegraphy serves as a means of translating the effects of the detector into audible signals. I must again refer you elsewhere (3) for a detailed discussion of detectors and their action, but I will call your attention to the fact that the two detectors named are *rectifiers* for alternating or oscillatory currents. [Lantern slides of oscillograms of the effect of the crystal detectors and the electrolytic detector on an alternating current wave were shown. (See P. W. T., p. 184.) From these slides you will see that the crystal-contact or

(3). P. W. T., pp. 140 **et seq.**

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the electrolytic detector, under the action of a small alternating voltage, permits the passage of a current in one direction but not in the opposite direction. The effect is one of rectification. The question might be asked what is the use of employing a rectifier with a Bell telephone receiver, since the telephone receiver responds to an alternating current, and does not respond to a steady, direct current. The answer is that the Bell telephone receiver will not respond to alternating currents of very high frequency such as are employed in wireless telegraphy, since (1) on account of the inductance of the receiver rapid oscillations cannot pass through it, (2) the diaphragm is not capable of vibrating with the high frequency of the waves, and (3) if it did vibrate with such high frequency we could not hear it because the sound produced would be of a pitch above the limit of audibility.

Now when the rapid oscillations produced by the electric waves are rectified into a direct-current impulse, the current thus modified can pass through the telephone receiver (4), which is in shunt with the detector, and will cause the attraction of the diaphragm. A second impulse, arriving say one five-hundredth of a second later will cause a second attraction of the diaphragm, so that with a succession of these impulses there will be a succession of vibrations of the diaphragm with the frequency, not of the oscillations of the individual waves, but of a pitch determined by the frequency of the arrival of the separate *trains of waves.* We thus hear, while receiving a wireless-telegraphic message a musical note with the fequency of the sparks at the sending station; that is, we hear a sound like that produced by the succession of sparks at the sending station. Now these sparks continuing for a short time constitute a *dot,* and for a longer time constitute a *dash* of the Morse code.

Let us next see how this process is to be modified in order that spoken words may be received in the place of the Morse signals. The essential change in the process consists in producing a *sustained sequence* of electric waves of high frequency in the place of the sequence of discrete trains, and in modifying this sequence of waves by a microscopic telephone transmitter. This sustained sequence of waves, when not modified by the vocal signals is of a frequency too high to produce audible effects at the receiving station. Let me next show one way in which a sustained train of waves may be produced, and first I will mention that a steady, direct-current source of power is employed to feed the system, in the place of the alternating-current transformer or induction coil of wireless telegraphy. For the general method of getting a pulsating current from a direct current we are indebted

(4). Detailed explanation in P. W. T., p. 142 and p. 173.

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to Dr. Elihu Thomson, and for great improvements in the method we are indebted to Mr. Duddell, and finally, the application of the pulsating currents so produced to wireless telegraphy and to wireless telephony is due to Mr. Poulsen of Copenhagen. I will de-

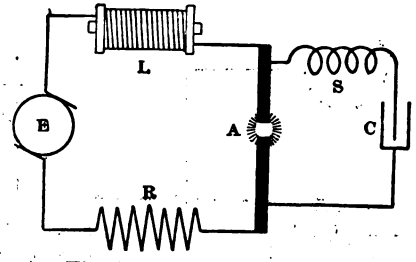

Fig A. Duddell's singing arc.

scribe Duddell's apparatus, with the aid of the diagram of Fig. A. An ordinary carbon electric-arc is shown at A. This is fed from a direct current dynamo at E through a resistance R and a choke-coil or inductance at L. About the arc is shunted a condenser in series with an inductance S. Mr. Duddell found that, with proper choice of the capacity, the inductances and the resistance, the arc emitted a musical note with a pitch determined by the capacity C and the inductance S. The pitch is also somewhat conditioned on the strength of current supplied and on the length of the spark. By varying the condenser capacity and the inductance S the pitch of the note can be varied.

[The Duddell apparatus was then demonstrated on the lecture table. The source of direct current was of 500 volts. The current used was regulated to values between ½ and 3 amperes. The condenser was adjustable as to capacity between the limits .007 and 24 microfarads. This changing of capacity in the demonstration was effected by a system of keys resembling the keyboard of a piano. By rapidly fingering the keys, thus throwing in more or less capacity notes of various pitches distinctly audible over the lecture hall were produced.]

The musical quality of the low-pitch notes resemble closely that of a bag pipe. The high notes are a clear, shrill whistle, and by using the smallest value of the capacity, .007 microfarads, the whistle is just at the upper limit of human audibility. Before attempting an explanation of this phenomenon I will describe and show the Poulsen arc.

Mr. Poulsen's adaptation of Duddell's arc to the purposes of wireless telephony consists in the following modifications. One terminal of Poulsen's arc (Fig. B.) is carbon (the cathode), the other terminal (the anode) is a hollow copper cylinder through which water flows for the purposes of cooling. The arc is in a

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water-jacketed enclosure filled with hydrogen or illuminating gas, and into this enclosure project the poles of a powerful electro-magnet N S, so as to give a strong magnetic field transverse to the arc. Current from a direct current source D passes through

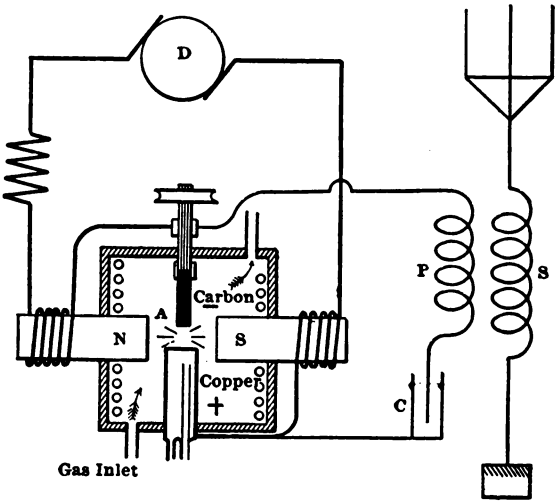

Fig. B. Mr. Poulsen's singing-arc generator of electric waves.

a resistance and around the iron cores N S of the magnet and thence through the arc. When in action, the carbon cathode of the arc is slowly rotated. In using this arc in wireless telegraphy or telephony, a condenser C is shunted about the arc and is in series with the primary coil P of an oscillation transformer. The secondary of this transformer is connected to the antenna and to the ground of the sending station.

The condenser circuit shunted about the arc sustains high-frequency oscillations, and these are impressed upon the antenna by the transformer P, S.

[This apparatus was exhibited, and the presence of high-frequency oscillations in the shunt-condenser circuit, which were above the limit of audibility, was shown by making P the primary of a Tesla coil. The secondary S, instead of being connected to the antenna and ground, as in the figure, was provided with spark terminals, between which a flaming arc established itself when the apparatus was in operation.]

Let me now give a brief explanation ([5]) of the manner in which these oscillations are produced from a direct current source,

(5). For a theoretical treatment of this subject the mathematical reader is referred to an article by H. Th. Simon, Physikalische Zeitschrift, Vol. 7, p. 433, 1906.

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and a reason for the superiority of Poulsen's arc in hydrogen over a similar arc in air. I call your attention to Fig. C, which shows the current-voltage characteristic of the carbon arc in air (Duddell's arc) and the copper-carbon arc in hydrogen (Poulsen's arc). These curves are from an experiment of Mr. W. L. Upson. Confining our attention to the carbon arc in air, it is seen that, with an increase of current through the arc, the voltage between the arc terminals decreases. For this reason, when the arc is connected in series with a source of voltage and is "struck" by bringing the terminals together and then separating them, the current through the arc tends to increase to a very large value, and must be restrained by a suitable resistance R in circuit with the arc.

Suppose (6) now, that when the arc is quietly burning, a condenser C and inductance S are together connected about the arc. The condenser begins to charge. This takes current from the arc and in consequence the voltage between the arc terminals increases; this causes more current to flow into the condenser. Finally, the condenser is charged to the same voltage as that between the terminals of the arc, but on account of the induct-

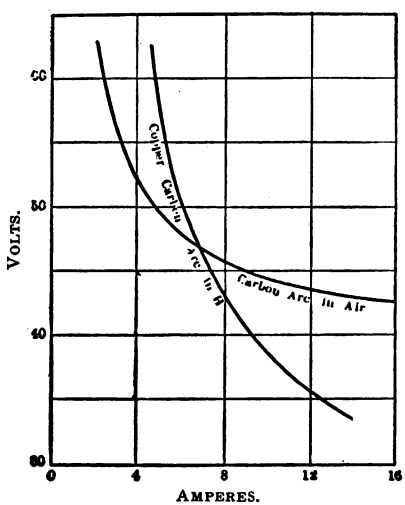

Fig. C. Volt-ampere characteristic of carbon arc in air and copper-carbon arc in hydrogen (Mr. Upson).

ance in series with the condenser the current into the condenser continues for a time after this condition is reached. This results in a potential difference at the condenser higher than that at the arc, which finally results in a cessation of the current into the condenser. The condenser then begins to discharge through the

(6). The succeeding two pages and all of the figures appearing in this abstract are taken from P. W. T.

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arc, causing a drop in the arc voltage and a further discharge of the condenser. While the condenser is discharging the inductance in series with the condenser tends to preserve the discharging current, so that the condenser potential falls below that of the arc. After the discharge has gone on to a sufficient extent, a minimum of condenser potential is reached, and the process again reverses.

The arc and the condenser circuit are thus in an unstable condition and the condenser continues to charge and discharge, thus repeatedly impoverishing and replenishing the arc as to current. Whatever energy is expended in this oscillation circuit is drawn from the direct-current source.

The fluctuating current through the arc, which is a path of conducting vapor, causes the vapor path to contract and expand periodically, and thus gives a continuous train of periodic disturbances to the air, which are heard as a musical note, provided their period of vibration is within the range of audibility.

It is, however, not the musical note, but the oscillating current in the condenser circuit, that is of interest in connection with wireless telegraphy and telephony. For the purposes of wireless telegraphy and telephony it is important that the frequency of oscillation should be high; namely, between one hundred thousand and one million per second. With the ordinary Duddell arrangement of a carbon arc in air this high frequency of oscillation does not seem to be easily obtainable, at least not with a large amount of energy in the oscillating circuit.

Poulsen's arc in hydrogen is an improvement in this respect over Duddell's arc in air, as may be seen by reference to the current-voltage curve of the copper-carbon arc in hydrogen (Fig. C.). The arc in hydrogen shows a greater fall of voltage with a given increase of current than does the arc in air. For this reason a more energetic oscillation of high frequency can be obtained from the arc in hydrogen than from the arc in air, as may be seen from the following reasoning:

To obtain the high-frequency oscillation a condenser of small capacity must be used in the shunt circuit; whereas for a slow frequency of oscillation a large capacity may be used. Now a small condenser, as is required for the high frequency, takes only a small amount of current to charge it, nd for this charge to be energetic it is essential that it should rise to a high voltage. It is, therefore, essential that the shunting of a small amount of current from the arc should cause a large rise of potential at the arc in order to get energetic oscillations in the shunt circuit. From the volt-ampere curve of hydrogen this is seen to be what happens in case the arc is in an atmosphere of hydrogen. In order to get equivalent steepness of the volt-ampere curve in air, it is seen to

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The Annual Address by the Vice-President was given by Mr. C. S. Griswold.

"SOME DEFECTS IN TEACHERS AND TEACHING."

One cannot teach school 20 years without having some positive ideas on the subject. They may be all wrong but they are positive.

One develops, too, a kind of frankness and may ask himself some awkward questions! whether his output has satisfied himself or the community; whether what he has handed out as education is what the people want or if they seem to want it, is it what they ought to have?

We like to bolster our calling with stories of Seneca, Roger Ascham—to tell of Bishops, Jurists, and Senators, who were schoolmasters, but Seneca has been found to have been a timeserver and the Bishops, Jurists, and Senators, one time teachers, admit that they did not follow that calling long

But whatever the condition of the teacher's calling in the past its state at present is somewhat parlous.

Those who ought to know tell me that the ranks are not beng recruited with the same quality of men as formerly—that the great educators of this and the past generation bid fair to have no successors. When the Pundits are asked to give the reason for their sad recessional and explain why the masters of the teaching art have so few disciples, their answer depends upon the angle from which they have observed the subject!—the inadequacy of the teacher's salary; earning the wage of a carpenter, car conductor or stone mason, yet expected to live in a manner showing a refined and cultivated taste: to associate with those who have such tastes and to develop it in those that haven't; the isolation or removal from the affairs of life, which is thought by some to be a penalty of the teacher's calling; the small chance of promotion, the uncertainty felt from liability to loss, or change of position through political wire pulling; the benumbing effect due to constant association with immature and uncritical or at least not constructively critical minds, and the consequent loss of ambition in the teacher; or perhaps more than all is the feeling that the social status of the teacher is uncertain; that the public, while bestowing rather perfunctory praise on commencement days and anniversaries, lets it go at that and neglects them thereafter, admitting by its actions, if not by its words, that it does not consider teachers as possessing much real influence in the important affairs of life, and living a rather theoretical life and dealing a good deal with unrealities, or perhaps it is the waning respect for scholarship that is everywhere apparent.

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These may or may not be the reasons for the failure of the teaching profession to attract the best men.

We are inclined to blame the public for the situation as if it were the result of its neglect. But on the other hand, as in the long run things are estimated for about what they are worth, it may be that the public is right and has put the correct appraisal on the education it gets. You talk with business men about their education and listen to their scorn of a good deal of it. Ask the senior about freshman work and hear him admit that he has forgotten so much that he could not pass the entrance examination to save his life. Imagine such a fate for instruction given the employees of a great business house, engineering firm, transportation company, good official officers of an armory. In other words, the boy is looked upon as a receptacle to accumulate instead of an organism to assimilate.

Education is too artificial. It is not made real enough to the boy. It has nothing like the reality to him of his play.

Play is the instinctive self-education of the child and indispensable because it is instinctive. Not all education can of course be play, since as such it would seem to lack the element of discipline, but play is not without its discipline although it may be of the unconscious sort; but play well deserves the study of educators as it possesses a something, which if applied to formal education, would give it life.

Most formal education is like studying bones in a museum. In his play the child clothes these bones with flesh and sees the animals themselves in their caves and dens.

At my little Summer School on Lake Asquam, where I take a few boys who have had difficulties with formal education, our applied mechanics is pretty well appreciated. Four of us one time removed from the roadbed with the help of several beams and smaller stones, a rock weighing nearly a ton. No one, I believe, who perspired over that stone will ever forget some of the applications of leverage and center of gravity. Or in building a pier to extend 70 feet out into the lake, supported by a crib of logs reaching 15 feet under water, resting on an uneven bottom and made strong enough to resist the pressure of the ice, the lessons in elementary, to be sure, but highly practical engineering are not the kind that need frequent reviewing to be remembered.

I wrote a paper a number of years ago with the somewhat cryptic title of the "Prologue of Education," in which I tried to show that as in his physical growth, the individual repeats the experience of the race, so should it be with his mental development; with his education.

As the race had blundered along with the the cumbersome Babylonian and Greek systems of enumeration, which allow only

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a slow addition and subtraction, but no multiplication or division to speak of, and welcomed the multiplication table with a sigh of relief as being a long wanted saver of labor, so the individual should not be introduced to a process until he had been made to look forward to its appearing as a friend in need.

The boy who has been obliged to extract long square, cube, fourth, and sixth roots by the usual process or a few of all roots by the exponential equation, will welcome logarithms, and will not look upon their mastery as a disagreeable task.

I have smiled often enough since at the naivetè of that paper as of course for the individual to repeat the experience of the race in a thorough-going manner is clearly impossible, as it is out of the question to artificially provide the situations with which life confronted the race.

The individual, as his time is shorter than that of the race, has to cut many corners and get much of his experience second hand, but the truth still remains that if you want to hit the moon aim at the sun, and while it is an unattainable ideal it is still an ideal and deserves to be approached as near as circumstances will allow.

The present time, it seems to me, is none too early to begin putting education on a broader basis of reality.

The United States is becoming rapidly more populous and the population is becoming congested in cities.

With a more artificial, highly organized life, young people are not called upon for little accomplishments as before. Sewing, mending, repairing, carpentering, etc., are done outside the home.

Not nearly so large a proportion of boys pass their boyhood on farms.

The farm is the natural laboratory and school of youthful enterprise. The boy there may be called upon to do any one of a hundred things from raising and breaking a yoke of steers, to mending the hay wagon, mowing machine, or painting the front gate, and he is usually enthusiastically prepared to do it.

Who knows as well as the farm boy the usefulness of a fence rail, piece of string, or pocketful of nails! The environment of the farm with its varied activities constantly appeals to the ingenuity and resources of the boy.

It is certainly significant that many boys, dunces at school floated along through the curriculum, intellectual outcasts, ill at ease and out of place, have qualified as men of rare business executive, inventive or other striking line of ability and equally so that the so-called bright boys, who always had their lessons did not realize expectations.

It justifies the suspicion that much of education is merely memory.

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The boy with a quick memory can appropriate much of the prevailing education and reproduce it in the required way.

The boy without memory or who does not acquire through memory, but needs to incorporate ideas in his own experience fails dismally in the contests of their process.

It is equally significant on the other hand that athletics have come forward into such prominence, and have won a place of recognized importance in education, and no less significant that the successful athletic trainer can name his price. He has something the public wants. He is a constructive factor and what he builds, if he has done his duty, doesn't have to be partly torn down again. I heard a distinguished and influential Harvard professor say that athletics were by far the most real things to the students and to some the only real things.

The obvious inference is that the program of subjects taught or method of teaching most subjects needs reshaping and vitalizing.

I am making this complaint against present day education to you because as teachers of physics, we deal with an educational subject in its nature concrete and real, yet with a subject that in the last decade has fallen off and failed to attract as it should.

There is, it seems to me, absolutely no excuse for this. Physics should be irresistible in its appeal to pupils by its vital contact with life and race experience, its program should be the model of method for other studies, and if it has failed in this it must be because it has been made somewhat too formal and artificial.

When in response to the suggestion of the committee of ten, the Harvard authorities required physical laboratory work as an entrance subject, there appeared a flood of text books which asked all sorts of questions, but never answered any—teaching you to observe they called it, expecting you to observe the laws of nature for yourself. This was in accordance with the correct theory, i.e. that the individual repeat the experience of the race, but it was most unsuccessful because one cannot repeat the experience of the race without he has in some way the environment of the race undergoing experience, and the race situation could hardly be created in the laboratory.

But the trouble is that while these reforming gentlemen were helping the boy to gain original knowledge based on his own experience, by putting into his hands the cherished apparatus never before trusted out of the teacher's sight, they were at the same time cutting off an indirect but, nevertheless, vivid source of experience by checking much of the eloquence of that gentleman, delivered while manipulating those sacred implements.

With the new order of supplying every boy with apparatus and requiring him to do the experiment himself, the mere serving of tables, getting out apparatus and directing its use took most of the

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time and strength of the teacher, and in consequence the old time carefully prepared demonstration table lecture was neglected, either through this lack of time or the belief that it was no longer necessary, but the results were most alarming for teachers were soon faced with the udeniable fact that the new physics with its laboratory additions was proving less attractive, less stimulating, less educative than the old fashioned natural philosophy.

By a process of reasoning by exclusion we are compelled to believe that there was more in the old time careful lecture table experiment method than was supposed.

Under the old Lecture System the teacher explained with great care, having the time for it and knowing that there was no other way whereby the pupil could obtain the knowledge, but this teacher did more. He created an atmosphere, he supplied an historical perspective, and when he got his effects with his apparatus on the demonstrating table, the pupil fully appreciated the causes.

For a boy to take a piece of apparatus apart, to put it together again and to operate it, is to impress his mind with its immediate principle by providing very real and intimate associations, but it does not cover the whole ground by any means. That successful experiment of his stands at the end of a long series of futile experiments on the part of others with inferior apparatus and under adverse conditions.

The boy must be told the history of the elaboration of that piece of apparatus: the mechanical and other triumph achieved before it was possible; the demands for results which made the discovery of this apparatus imperative.

He must be carried through the long struggle of the race and confronted with their problems, often hopeless, until in his present experiment they find their answer.

You remember when you read William Tell, how vividly the Alps stood before you, and the revolt of the hardy independent Mountaineers was just what was expected, so deeply had you been made to feel the justice of their cause. Yet Schiller had never seen Switzerland except in a few histories and geographies.

The critics of Homer admit that while his heroes were not real people but only imaginary characters; mere forms, nevertheless they were "forms more real than living men."

In other words these two great teachers by means of other genius as poets, through a few characters and situations of their own creation, taught the lessons of race experience and suffering, condensed in a few episodes the finding of history extending over many centuries. By this same token every teacher must be something of a poet. Poets are said to be born and not made but then so are teachers.

The teacher of Science with his specimens and apparatus tell-

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ing their own story is too prone to forget this and believe that there is no more to be done. His specimens and apparatus are not however the whole sermon—they are only texts—highly suggestive and highly self explanatory texts, to be sure, but still only texts, and needing the expansion of the sympathetic mind, which must bring to task a kind of ability a little short of inspiration.

The defect in this requirement of teaching is that it calls for qualities none too common in the race at large and hence hardly to be monopolized by the teaching profession; but the requirement is inevitable, and perfect or even satisfactory conditions will not be realized otherwise under the present conception of teaching.

The alternative is that through some radical departure or great upheaval, the conception of teaching methods may change. Even now there exists an organization which, if reports are true, seems to promise that the new conception is near at hand.

I refer to the Boy Scout movement. Among these through the romantic interest and enthusiasm always aroused by the characters of the soldier and the knight, the boy performs the otherwise irksome duties and services with all the old time zest of chivalry. What is usually acquired by hard uninspiring study, now, because a use is provided for it, or a demand created for its results later, is accomplished with all the enthusiasm of a splendid game. The spirit of play sublimated to the point of devotion to an ideal—The method is most completely justified by its element of the spirit of play, because it is in play that the child instinctively expresses itself.

Whether the method of development and cultivation shown in the Boy Scout movement can be applied to formal education, no one can tell and it is probably doubtful in its present form, but that feature of it which enlists the boy's interest and enthusiasm by linking his education with his activities and which acquires education as a whole, rather than in small dribblings from the present watertight compartments, must figure largely in whatever form the new movement takes.

The teacher of Science, and Physics in particular, is too apt to take a somewhat narrow and technical view of his subject and the more he knows about Physics, to be the less willing to mix anything else in with it in his teaching. Carried so far in many cases that often those who know very little Physics, are better qualified to teach it than those who have made it their specialty, because the former have a better perspective.

Our task as a teachers of boys of the preparatory school age is to educate along general lines with a view to contact with other subjects and Physics itself on its historical imaginative, and even poetical side, rather than to specialize and become too technical.

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And that some such calamity has befallen the subject is evident from its waning popularity.

The laboratory work feature for Physics Teaching is undoubtedly invaluable and indispensable, but it is worth while. I claim, to regain the good points of the old regime and to teach Physics with more regard to careful and complete lecture table demonstration—to work up to its principles more gradually and naturally and to be content to make it a dependent part in a great living whole, rather that a self reliant unit in splendid isolation.

In no other way, to my mind, can the boy be so influenced by the personality of his teacher, and the degree to which the personality of the teacher is effective is a test alike of the teacher and the method of teaching.

One of my old boys came to me from a famous government academy and when I asked him about his teachers said, "Well, you know, we don't get very much from them, they are only a sort of marking machines." And a little questioning showed that he was taking a very impersonal sort of interest in his studies and looked upon them as a means to an end, rather than as an end in themselves.

I was impressed by this incident with the importance of personal association. Also with the fact that the boy knows when it is lacking, and has a feeling that he is missing something.

To come back to about where I was at the beginning of this paper, the educational world is in a condition of unrest of which the dissatisfaction of and with teachers and teaching is only the outward and visible sign.

Life, for which education is intended to prepare, has so changed its conditions that education has not been able to meet the new requirement.

Today, education has become not a privilege of a class or classes, but a necessity for all mankind.

To meet the demands of this new situation any educational creed to be workable must be cast upon the broadest lines.

At intervals, to avoid excesses and abnormalites, the world has been obliged to cut away its flimsy, artificial creations, to get back to nature and make a fresh start.

Professor Osborn in an address before the students of Columbia on Huxley on Education said, "I would not for a moment take advantage of the present opportunity to discourage the study of human nature and the humanities, but for what is called the best opening for a constructive career give me nature.

Our Science is secure. I can imagine no program of education, be it the creation of Faddist or Prophet, that will not include it, it is so near the roots of things.

It is destined to continue to exist, but it should do infinitely

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more. We can properly require of it that it contribute largely to the expanding, unifying and humanizing process, which must precede the appearance of a better conception of the Theory of Education.

But it should first set its own house in order. Eliminate much of the merely formal and unsuggestive. Appreciate and employ the tools of imagination and historical perspective. Emphasize its human side and develop it through all its points of contact with life.

Then it can go forward and expect with confidence to share in the establishment of the new order of things in education, which is sooner or later sure to come.

BUSINESS.

A vote of thanks was given Professor Pierce for his interesting address.

On recommendation of the Executive Committee the following persons were elected to membership:

Active,

Mr. Wallace Richmond, Newton High School, Newtonville, Mass.

Mr. Leon Varnum, Newton Technical High School, Newtonville, Mass.

Mr. Harry F. Wiley, Laconia High School, Laconia, N. H.

Associate,

Mr. Carleton E. Preston, English High School, Boston, Mass.

Mr. William E. Wing, Deering High School, Portland, Me.

The secretary read the following resignations:

Active,

George W. Earle, Hyde Park, Mass.

W. Hollis Godfrey, High School of Practical Arts, Boston, Mass.

Frederick Winsor, Middlesex School, Concord, Mass.

Associate,

Miss Eldora J. Birch, Hartford, Connecticut.

The President then called for reports of standing committees as follows:

ON NEW APPARATUS.

Mr. Hall, chairman, first called on Mr. LeSourd of Milton Academy.

Two experiments which make use of electric bells were described by Mr. LeSourd. In one of these, each pupil is given one dry cell of battery, two electric bells, some pieces of wire and a block having two keys which act as buttons. The following combinations are to be set up and diagrams for each placed in the note book.

I.—Button 1 rings both bells.

II—Button 1 or 2 rings bell 1.

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III.—Button 1 rings bell 1. Button 2 rings bell 2.

IV.—Button 1 rings both bells. Button 2 rings both bells.

V.—Button 1 rings bell 1. Button 2 alone rings nothing. Buttons 1 and 2 together ring bells 1 and 2.

VI.—Button 1 rings bell 1. Button 2 rings both bells.

The second experiment makes use of a board about eight inches square having on it two binding posts, a two-way switch and four loose ends of wire. On the under side of each board are wires which connect the various points on the board and these wires are concealed by a cardboard cover tacked onto the rim of the board. By means of a templet having holes corresponding to the fittings on the board, sheets of paper may be marked so that when cut and placed on the board the switches and binding posts will project through these holes and the paper lie smoothly on the board. These holes may be cut through a number of sheets at once by clamping the sheets between two soft pine boards and then boring holes through wood and paper with a brace and bits. One sheet of paper being placed on each board with thumb tacks, the pupil by means of a battery and electric bell tests the binding posts and switches from point to point successively in order to locate the concealed wires. After the pupil had drawn a complete diagram of the wiring as he expects to find it, he is allowed to remove the cardboard back and he draws in dotted lines on the same paper the actual wiring of the board he has used, and the sheet of paper is removed and preserved in his notebook as the original record of the experiment. The experiment gives the class a practical method of locating short circuits and broken connections in electrical appliances.

Mr. Andrews of South High School, Worcester, showed two pieces of apparatus made by Max Kohl. These were models of the Newtonian and Galilean telescopes showing the relative positions of the lenses and also showing in diagram the paths of the rays on the white mounting boards. Can be secured through Eimer and Amend. Price, $3.60. A set of carefully made wooden blocks of increasing densities shown. Student can measure them with great accuracy and then weigh and calculate specific gravity and density.

Mr. Wells showed an Automatic Safety Gas Lighter, $1.

Can be secured by writing 26 and 28 Wingate Street, Haverhill, Mass.

Mr. W. F. Rice showed a small piece of brass adjusted to a pinch cock to prevent cutting rubber tubing.

Mr. Clarence Hall:—

A MODEL PILE DRIVER.

The apparatus is an attempt to illustrate the meaning of "the force of a blow" and to determine the relation between the energy of a falling mass and the work it can do when it strikes an object.

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The apparatus consists of a steel plug fitted to slide with some friction in a brass sleeve which can be adjusted for wear, so as to keep the plug from sliding too easily.

The plug is driven by the impact of a lead disc falling a known distance, freely as far as possible, guided slightly by three vertical rods which form the supports of the apparatus.

The rods are screwed into a top plate of triangular shape which has a threaded hole in its center.

The exercise is performed as follows: The lead disc is weighed and the distance it can fall to the head of the plug is measured.

The plug is set flush with the lower side of the brass sleeve, the disc is raised and let fall the full amount measured.

The impact drives the plug a short distance through the sleeve, and the distance measured to hundredths of an inch.

The next thing is to determine the constant friction force that the plug experienced and this is obtained as follows: Through the threaded hole in the top plate is now screwed loosely the threaded short arm of a rod bent at right angles, to the longer arm of which it attached a spring balance. A second rod is now inserted from the top of the plug to the end of the screw arm and the pull on the balance read when the plug is moved a small distance by turning the screw down.

From the laws of the lever and screw, one can calculate the thrust on the plug which is assumed to be equal to the friction on the plug when it was driven by impact.

Multiplying the friction by the distance the plug moved under impact gives the work done on the plug.

Multiplying the weight of the lead disc by its fall, gives the energy in the disc at impact. The two quantities come out nearly equal, within four per cent. in some tests made on this apparatus. Several errors are involved.

The plug may not be exactly straight and the friction may not therefore be the same at all parts of the motion of the plug, hence we must move the plug only a small distance by the impact, so as to keep the friction as nearly constant as possible. This small distance is hard to measure accurately, hence here is another chance for error.

The lead disc loses some energy in friction against the guide rods.

The method of obtaining the friction of the plug involves the friction of the screw thread in the top plate, hence this must be well oiled and the screw made a loose fit. By making the radius of the screw small the friction error is reduced.

The apparatus is used for student work and in lectures.

An exercise in moments and center of gravity. Problem: To predetermine the place to set the ball of a lever safety valve to open at a given gauge pressure.

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The parts are weighed and the arms of the forces are measured. The center of gravity of the lever is obtained by balancing. The diameter of the valve is measured and its area calculated. From these data, letting X be the distance from the fulcrum to the center of the ball, we can by moments calculate the arm X for say 60 lbs. per sq. in. Then the apparatus is assembled and the ball set as per calculation. The apparatus is then attached to the water supply and the gauge read when the valve blows off. The gauge reading gives an idea of the accuracy of the student's work. Ordinarily the gauge reads within 2 lbs. per sq. in. of the predicted value, 60 lbs. to sq. in.

A GAUGE TESTER.

This is an apparatus to illustrate the relation between height of mercury column and pressure in pounds per square inch, also for testing or calibrating a gauge.

It consists of a gauge connected to a U-shaped glass tube of mercury, a branch tube being provided for attaching an air pump for changing the pressure in the gauge and tubes.

In use, the air pump is attached and the pressure made about one pound per square inch. Gauge, both mercury columns are read, and from the difference in level the actual pounds per square inch are calculated from the pressure formula. Comparing this with the gauge reading gives the correction for this point. Continuing in this way, readings are taken every pound and a curve plotted between the true pressure and the gauge pressure, thus giving a calibration curve.

If the mercury column is plotted against the gauge pressure, the curve is nearly a straight line, showing that the pressure is directly proportional to the height of mercury column.

This exercise works very well as a student's exercise and the apparatus is useful as a lecture piece.

Professor Hall of Harvard showed a new form of balance having flat back for maintaining in horizontal position and a long slot so that zero error can be easily found. Sells for $1. It is recommended for parallelogram forces experiment.

Can be secured of John Chatillon & Son, New York.

Mr. Hall also showed a qualitative experiment showing why a ball can be supported on a jet of water. This apparatus consists of a spool supported on a thin flexible brass strip. Shows clearly how forces act.

REPORT ON MAGAZINE LITERATURE.

Mr. Sears chairman.

Cassier's Magazine.

June, 1910. Synchronizing Alternators (S. G. Winn). Electro-Mechanical Locomotives (A. P. Chalkley).

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August, 1910. Balancing of Reciprocating Engines (R. J. Grimshaw). (Very good.)

November, 1910. Engineering at the Sheffield Meeting of the British Association.

Century.

June, 1910. Bird Flight and Air Navigation (T. R. MacMechen and Carl Dienstbach).

October, 1910. The Evolution of Flying Man (Augustus Post). (Incidents in the experiences of Glenn Curtiss.)

Electrical World.

July 7, 1910. Electric Lifting Magnets in the Steel Plant.

July 21, 1910. Results with Edison Storage Battery Car

July 21, 1910. The Physiological Tolerance of Alternating Current Strengths up to Frequencies of 100,000 Cycles per Second (A. E. Kenneally and E. F. W. Alexander).

Sept. 22, 1910. The Electrical Equipment of an Air Ship (The America), (Frank B. Rae, Jr.).

Nature

Aug. 4, 1910. The Leaning Tower of Pisa. (Comments on report of a Commission of Inquiry.)

Popular Mechanics.

July, 1910. The Ultimate Unit of Electricity (Francis J. Schulte).

November. 1910. Manufacture of Artificial Ice (J. Gordon Ogden, Fifth Avenue High School, Pittsburg).

Popular Science Monthly.

August, 1910. The Status of the Ether (Prof. A. G. Webster, Clark University.) Physiologic Light (F. Alex. McDermott).

November, 1910. Recent Developments in Physical Science (Prof. A. L. Foley, Indiana University).

Science.

July 15, 1910. The Apparent Sinking of Ice in Lakes (Brige).

July 29, 1910. The Teaching of Elementary Physics.

August 26, 1910. The Luminosity of Comets (Dudley).

Scientific American.

September 17, 1910. Foucault's Pendulum Electrically Propelled (Dr. Charles Forbes, Columbia University).

October 15, 1910. Apparatus Exhibited at the Exposition of the French Society of Physics (Jacques Boyer).

Scientific American Supplement.

September 17, 1910. Atmospheric Electricity (Charles E. Benham). (A review of recent researches.)

September 10, 1910. Is Matter Eternal? (F. W. Henkel, B. A., F .R. A. S.)

October 8-15-22, 1910. The Isolation of an Ion (Prof. R. A. Millikan, University of Chicago).

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October 29, Nov. 5, 1910. Telegraphy and Telephony (Sir John Gavey).

School Science.

October, 1910. Physics as a Factor in Forming Character.

October, 1910 (page 638). Construction of Electrolytic Interrupter.

October, 1910 (page 642). Microscopic Projection Apparatus.

World's Work.

August, 1910. The Passing of the Man with the Hoe (Edward A. Rumely). (An article describing the progress in use of power machinery for farming in the West.) How the Wrights Discovered Flight (Arthur W. Page).

September, 1910. How to Learn to Fly (Augustus Post). Control of Water Power (Henry L. Higginson).

October, 1910. South America's First Transcontinental Railway (Charles W. Furlong).

REPORT OF THE COMMITTEE ON CURRENT EVENTS IN PHYSICS

Roger C.Chittenden, Chairman.

S. Y. Beach of New York is working on auto stability of aeroplanes by use of a gyroscope revolving in a vacuum. Although this would relieve the steersman of all thought and worry in balancing the planes, it would make quick manoeuvering impossible, and could not be used in landing where instantaneous shifting is essential.

Much progress has been made in aeroplane construction, but most of the advance in flying is due to increased knowledge of the conditions of the atmosphere and to improvements in motors.

Over the short course at the International meet at Belmont Park, one of the Wright brothers, using less than full power, developed a speed of 64.9 miles per hour. LeBlanc made 66.6 m.p.h. over the long course. The Wrights' small machine showed a lifting power of 6.5 lbs. per square foot of wing spread, or 14.6 lbs. per h.p. LeBlanc's Blériot developed only 4.7 lbs. per square foot or 8 lbs. per h.p.

Ralph Johnstone was killed on November 17 in a 500 ft. fall, due to the collapsing of a wing in a dangerous manoeuver. He holds the world's altitude record of 9714 ft.

Purification of water by ozonization has been successfully tried by several foreign towns. Air is forced through a chamber, where it is subjected to a high voltage discharge. This air is then passed up through a tower containing sand filtered water, and all the germs contained in it are destroyed.

Plans are on foot to light the streets and public buildings of the District of Columbia with electricity generated at a proposed power house at Grand Falls on the Potomac.

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An international committee has been formed to decide on a standard for measuring the strength of radium and radio-activity. Mme. Curie is to prepare a standard containing about 20 mg. of radium which is to be preserved in Paris. The unit adopted for measuring the amount of radium emanation is to be called the "curie"—the mass of radium emanation in equilibrium with one gram of radium. Samples will be compared with the standard in their power of giving off highly concentrated X rays, and measured by an electroscope without opening the sealed standard container.

Mme. Curie is reported to have succeeded in separating pure radium.

In order to prevent cutting of communication with the National Capitol by storms, a wholly underground duplex cable is to be laid between New York and Washington. Three telephone and six telegraph messages simultanously will be possible over each wire in the cable.

The Marconi station at Glace Bay, N. S., is now open and exchanging messages with Clifden, Ireland, 1700 miles away. Glace Bay has a sending radius of 3000 miles.

New inventions in portable instruments are expected soon to make photo-telephoning a quick and inexpensive process. Experiments are being carried on near London.

A new clinical thermometer consists of a coil of fine platinum wire connected with a sensitive galvanometer and an ink tipped pointer moving over a drum. The coil is placed under the arm pit of the patient, and change in its temperature varies a current passing through it. This change is recorded on the revolving drum.

Old dry batteries may be temporarily revived by placing in a bath consisting of half a pound of blue vitriol and enough water to rise at least half way up the side of the battery. In an hour it will be ready for use again.

A German process provides for the use of electro-deposited nickel plates in place of the havy and expensive lithograph stones.

Tilling the soil by exploding in it rows of dynamite cartridges has been successfully tried in the West.

Ostend, Germany, has a suspended electrical ferry running on a girder 80 feet above the water.

Time signals are sent by wireless every midnight from the Eiffel Tower, so that mariners may have correct time, which is so necessary in taking observations.

Peter Cooper Hewitt has won a long legal battle in the U. S. courts over the patent rights of his rectifier.

An immense windmill is to be used on a farm in Bristol, England, to generate electricity to light 300 lamps, run an elevator, grind corn, cook and heat at a cost of one cent per unit.

A good aluminum solder is said to be composed of 6 parts of

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aluminum, 2 of zinc, and 4 of phosphor tin. Stearic acid is used as a flux.

REPORT OF COMMITTEE ON NEW BOOKS.

Will'am F. Rice, Chairman.

A Text-Book of Physics by C. E. Linebarger. Pp. viii, 471. D. C. Heath & Co., Boston, 1910.

There is a laboratory manual and teachers' manual in preparation to accompany the book.

Those who pick up this book expecting to see something radically different, or even new, in the way of a text-book will be disappointed. At first sight, and on closer inspection, too, it will prove to be just another physics book, and it is worthy of consideration only if it does well what we ordinarily expect a text-book to do. Let me say, right here, that the book justifies this consideration.

In form the book is less than one inch thick, though only 5 1-4 x 7 1-2 inches in its other dimensions. It is well bound, opens nicely, and it is a good book to hold. It would be an improvement if the paper had less glaze.

The book is a safe and sane treatment of physics, steering a wise course, neither ultra-radical nor ultra-conservative. It does not, then, demand so much discussion of the principles of its construction, for they are the ones generally accepted today, as it does a consideration of the way these are carried out.

The book is divided into 25 chapters, distributed as follows: 9 on Mechanics (1-3 of the book), 4 on Heat, 4 on Sound and Wave Motion, 3 on Light, 5 on Electricity and Magnetism.

The author's style is commendable for its clearness. The definition of coefficient of linear expansion, taken at haphazard, is an illustration of this: "The increase in length which the unit of length of any material undergoes when its temperature is raised one degree." Historical references are frequent, but there are no portraits or biographies of scientists. Two sizes of type facilitate the giving of a short course. Considerable use is made of mathematical treatment, and, in my opinion, the book is not adapted to the first year of high school,—not even the shorter course.

The author claims he has made numerous references to practical applications of principles. To the reviewer, the number seems satisfactory, but not especially noteworthy. The book is copiously illustrated; the illustrations are appropriate, however, and it does not take on the character of a picture book. The continued appearance of one firm's name on pictures of apparatus is objectionable. A few of the cuts are too small to show essential details; some of these are those of the barometer, the metallic thermometer, the microscope, and the defects of vision. Others can

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be commended for clearness and originality; such a one is that showing the action of the achromatic lens.

Exercises are numerous and well-chosen; nearly 230 were counted in Mechanics. There is an occasional tendency to an impractical degree of accuracy. Illustrations of this are seen on p. 120 where, in problem 9, g is carried to three decimal places (in c. m.); and in problem 10 the value of is given to five decimal places. It is even questionable whether it is wise to carry weighings to centigrams in specific-gravity problems. There are problems in each group, however, which present no undue arithmetical difficulty. Questions are not confined to the English or Metric units, but each is indiscriminately used. The following are samples of the many good exercises: "Account for the fact, first observed by Rumford in 1788, that the barrel of a musket, fired without a bullet, becomes hotter than when a bullet is discharged." "Hold the palm of your hand close to your mouth and breathe gently upon it. Does the breath feel warm or cool? Blow as hard as you can against your palm held farther away. Account for the difference of sensation which you experience." "The seventh overtone is discordant with its fundamental. How is the hammer made to strike the strings of a piano so as to nearly obliterate this tone?" "Why is it that steel tools that have just been tempered are not magnetized, while after use they often show magnetic behavior?"

The author plunges into the laws of bending and stretching in Chapter I. These laws are used for illustrating the methods of physics in the Introduction. This seems to me a questionable procedure. It is interesting to note that, while acceleration is taken up on p. 58, falling bodies are not reached till p. 103, two chapters on other topics, intervening. I object to what amounts to advising the slipshod way of expressing an acceleration; for example: 30 ft. per sec., instead of 30 ft. per sec. per sec. There is no description of the Fortin barometer, though a small and inadequate picture is shown.

The author defines the metric absolute units, but makes no extended use of them. He acknowledges that "so much of practical work consists in moving bodies upward against gravity, that weight or gravity units are more frequently used than absolute units." Yet in discussing the efficiency of a steam engine he uses absolute units. This is out of place in a text-book for use in American high schools. The value of the mechanical equivalent of heat is given as 774 ft.-lbs. No authority for this is mentioned. Sixteen pages are devoted to wave motion, considerable space being given to harmonic motion. An interesting application of theory is the explanation of why waves in the ocean tend to become parallel to the shore line. The dissociation theory is

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presented in a simple yet lucid way. It is used in explaining solution tension, action of a voltaic cell, and electrolysis.

Especially to be commended is the presentation of the water analogy of the voltmeter; in fact, the whole treatment of potential is noteworthy. In these days when so many boys have "wireless" outfits of their own, often of high efficiency, is it not desirable that a good text-book, if it describes wireless telegraphy at all, should refer to other detectors, as well as to the coherer of metallic filings?

In conclusion, the reviewer is emphatic in saying that if any teacher is not now satisfied with the book he is using, or is considering the adoption of a new text-book, he ought not to fail to examine this book.

WILLIAM F. RICE.

Mr. Rice read Mr. Jackson's paper.

A High School Course in Physics, by Frederick R. Gorton. Pp. xiii, 480. 1910. D. Appleton & Company.

The standpoint and purpose of this book are indicated by these quotations from the preface: "Physics is a summary of a part of human experience." ". . . the presentation of the subject in the secondary school should be the expansion of the everyday life of the pupil." "Large portions of the subject matter of Physics deal with knowledge already possessed by a pupil of high-school age."

Those who are in sympathy with the view of the relation of Physics to school work which these quotations express, will find this one of the most satisfactory of the textbooks now offered for our use. This is one of the series of "Twentieth Century High School Text-Books in Natural Science," and, as the name of the series would imply, it aims to be fully abreast of the times. Some of the newer subjects treated are, steam turbines, moving-picture machines, and aeroplanes; in the last case diagrams are given showing the resolution of wind force on the planes. There is no undue prominence given new topics, for the sake of appearing up-to-date. Some of the familiar things utilized in relating Physics to common life are, the meat chopper, the coffee grinder, the sewing machine, the fireless cooker, drying clothes, and removing grease spots. There is no forcing of these homely subjects upon the attention, but a recognition of useful applications of the truths of Physics.

The dominant characteristic of the book is clearness. Some of the ways in which this virtue is illustrated are noted here. The chapters are compartively short; each chapter is divided into several sections, each of which treats a distinct topic; at the end of almost every section, and sometimes in the middle of a section,

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there is a short set of exercises, applying the principles which have just been given; in the first third of the book there are over thirty of these sets, containing nearly three hundred exercises. At the end of each chapter is a summary of what has been taught in the chapter, with a reference to the numbered paragraph in which each principle stated was discussed. Two kinds of type are used in the text; they are of such size, and the spacing is such as to make an attractive page and one easily read. The soft finish of the paper spares the eye the glare which is unpleasant in some books. Pictures and diagrams fit the text; they help to illustrate it and are explained by it. The statements are made in clear and direct language.

Most of the qualities here commended are displayed in varying degrees by many other books, but there are few books which present so large a number of them in so large a measure.

Portraits and sketches of twenty eminent physicists, from Newton to Madame Curie, are inserted in close proximity to the topics to which their discoveries are related, the sketches being calculated to show what the work was for which each was distinguished.

While the book is designed to meet the needs of the ordinary pupil in the High School, it claims to contain everything that is asked for by the College Entrance Requirement Board. I have not tried to verify this claim, but I have no doubt it is well founded. W. D. JACKSON.

Mr. Rice called on Mr. Fred Cowan of the Girls' Latin School, Boston, to give some additional facts in regard to Gorton's Physics.

Mr. Cowan:—

A Review of Gorton's "High School Course in Physics."

The book presents the material usually taught and considered important in secondary school work in such a way that it can be intelligently read by pupils of the last three years of the high school. The author has succeeded admirably in expressing what he has to say briefly and clearly in simple language.

The book is made especially attractive by the introduction of twenty excellent portraits of famous scientists, each accompanied by a suitable sketch. The sketches, as well as the portraits are bound to attract the attention of the pupil and increase his respect for science.

There are twenty-one chapters in a book of 480 pages, so that the chapters are not too long.

The diagrams are sufficient in number and well chosen. Simple illustrations prevail, and it is left to the teacher to supply pictures of complicated machinery, if he wishes to do so.

The book should meet the needs of many teachers of physics,

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and deserves thoughtful consideration before a choice of a new book is made.

Mr. Butler:—

Review of Mann & Twiss' Physics (Scott Forsman & Co., 417 pages).

The authors state that their aim is to make the text significant to the student. With this in view, the presentation begins with an example followed by an explanation, and ends with the definition.

The subject matter is divided into two parts, making, as it were, two volumes in one. The first part includes only the elements, and might well be used in a first year physics class. In the second part appear such topics as Compound Machines, Friction, Aeroplanes, Heat Engines, Absolute Temperature, Compound Steam and Gas Engines, Turbines, All Image Diagrams, Index of Refraction, Optical Instruments, Static Electricity and Wireless, Energy of Motion, Absolute System and Molecular Physics come at the end of the book.

Great stress is laid on electricity, 85 pages, and the subject well presented. Here, particularly, are the diagrams especially clear and instructive. All magnet coils are represented by a few turns, showing complete circuit. Throughout the book the half tones common to the first work by the same authors, have been replaced by clear line diagrams. These are rather poor under optics, particularly the optical instruments.

At the end of each chapter is a resumé that would be useful in review. It is, as the authors claim, a brief summary of the points brought out in the chapter. Following this resumé are questions, and then, lastly, any problems that may be given. Problems and questions are thus kept separate.

The authors seem to have profited by the criticisms of their former work and have turned out a product that is a great improvement on the first effort. The book seems to be one that can be used successfully in college preparation.

At the close of the meeting Mr. J. W. Hutchins distributed copies of the report on "Teaching of Physics in Small High Schools."

EVENING SESSION.

Boston City Club, 9 Beacon Street.

Dinner at 6.30 p. m. Thirty-nine members present. The guests of the Association were Mr. William Orr, Deputy Commissioner of Education; Mr. John W. MacDonald, Agent of State Board; Mr. Briggs of Chelsea Board of Control; and Mr. Nickerson, Superintendent of Schools of Medford.

After a fine dinner had been enjoyed, President Greenlaw called on Mr. Hutchins to give the history of the "Report on Physics in Small High Schools." Following Mr. Hutchins, others were called on. A brief abstract is here given:

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Mr. Hutchins:—

The "Report" speaks for itself. Our Association is made up largely of teachers from the larger high schools. In this "Report" we have attempted to reach the small high schools. We have collected data from schools of from twenty-five to one hundred fifty pupils, all over New England. We have received many replies. The data and results have been tabulated and appear in the first few pages of the report. Some interesting data have been received nd summaries made therefrom. Two or three pages have been given to essential methods and to summarizing them. There are a few general recommendations as tc relative time of laboratory and recitation periods, and as to home resources. A list of thirty experiments from "College Entrance Board List" is given, which seems to be satisfactory and covers the ground well, and seems to be within the resources of teachers and apparatus of small schools. A list of more essential names of prominent apparatus dealers is given. We have tried to make the Report attractive enough to cause a teacher to keep it by him for reference.

On motion of Mr. Packard a vote of thanks to Mr. Hutchins was unanimously passed.

Mr. Waterman of Smith College was called on as one of the Committee who had prepared the report.

Mr. Waterman stated that he was interested because of the condition in which pupils come to him, and the condition of those who go out to teach Physics. It is a wonder that pupils do as well as they do. Anything in the way of a definite and a concise statement of help to those who are forced to teach Physics will be welcomed. This report embodies many things that will be helpful to young teachers.

President Greenlaw called on Deputy Commissioner of Education, Mr. William Orr.

Mr. Orr said that he began as a teacher of science. He stated that he supposed he had done the things he ought not to have done, and left undone the things he should have done. High schools now are improving in equipment, and are getting beyond the pail and dipper stage to which one speaker had referred. We must not underestimate the importance of small high schools. Probably not more than one quarter of the schools have special teachers of Physics. The Report merits all that can be said of it. Much work has been spent in tabulating and classifying data. The Report gives an understanding of administrative problems. Normally, at least, much laboratory work is being done.

Mr. Orr suggested that questions thirteen and fourteen of the Report give a chance to further investigate and work out the problem of better instruction in small high schools. The Summary gives a clear, definite and concise history of the last thirty

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years of teaching. There now seems to be a tendency to two courses in Physics; the first, elementary; the second, more formal. A general course may remedy the unfortunate fact that few take Physics. Each pupil should have some training in Physics, a subject that should grip young minds. By it they should develop ability to work along lines of investigation, should learn to understand movements of the present day, and should better fit themselves for their duties as citizens. We are amazed at the extent to which Physics is applied. There are too few taking Physics in larger high schools. No pupil should go out without the basic facts of that science. The Colleges offer a definite program. What have the high schools to offer? The teachers of small schools are too limited to suggest a course. Here is a great field for organized experience. Ways and means should be devised to better fit those intending to teach Physics.

Mr. MacDonald, Agent of State Board of Education, said that complete harmony did not exist in the State Board, but the difference is a difference in good methods. He wished the Report had gone farther, but criticised what seemed to him a mixture of elementary and laboratory courses. He said that the elementary and laboratory methods should be separated and cannot be carried on side by side. The elementary course should teach the most possible of all those things that all men and women ought to know. It should teach those things that should help interpret the other sciences, and should lay a foundation for appreciation of laboratory work. Not one in five should be allowed to go into a laboratory.

Mr. MacDonald gave copious illustrations of results and methods from his own experience.

Mr. Black stated that he came into the work only in time to see the immense amount of work done by Committee and Chairman.

Mr. Briggs of Chelsea, a former teacher, told in a humorous way of some of his early attempts to teach temperance and coefficient of expansion. Nature study, he stated, perhaps should be carried from grammar to high schools in the form of elementary science.

Mr. Nickerson, Superintendent of Schools of Medford, spoke in sympathy with the general stand of Mr. MacDonald. He deplored the fact that so few are studying Physics. He will be very glad if something may be done to give adequate courses.

Prof. E. H. Hall of Harvard said that he was much interested and pleased. We have in the laboratory method neglected the qualitative side. The laboratory method must be supplemented by lectures and recitations. Some have overdone the laboratory work; many have not time, some are not competent. Many schools have not proper equipment. Beside better training of teachers and better

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equipment, manual help is necessary to do the drudgery, leaving the teacher more time for preparation.

Mr. Boylston spoke in favor of Elementary Science, and told of the popularity of one class in that subject.

Mr. Packard said that languages have crowded out sciences. He made a strong plea for more time. Harvard dominates Physics. The three who enter there count for more than the 77 who go out happy. Many who have ingenuity and cut loose get criticised.

Mr. Lowell of Providence said that we do need to emphasize practical applications and get back to qualitative work. Parents need to be educated. The present time is a good one for the industrial education movement. The only opposition is from parents. The quantitative work will be sought by those who need it.

Mr. Wiley, a newly-elected member, spoke briefly of conditions in New Hampshire, and stated that these conditions have been improving for the last few years.

Mr. Orr now suggested that The Eastern Association could well be a clearing house for all that is best in our work.

Mr. A. B. Kimball suggested more choice of material and less rigid requirements. Mr. Burke, Mr. Brayton, and Mr. Peterson spoke of the numbers in their schools taking Physics.

Mr. Waterman closed the discussion by a brief defense of the Report and the college requirements, and said that a great deal of good may result by getting together those of different views.

Meeting adjourned at 10.50 p. m.

RALPH CHANNELL, *Secretary.*

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PROGRAM OF

THE FIFTY-EIGHTH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, March 25th, 1911

at Robinson Hall, Tufts College

9: 30 *A. M.*

Meeting of Executive Committee.

10: 00 *A. M.*

Business.

Annual Report of the Secretary.

Annual Report of the Treasurer.

Report of Standing Committees:—

On New Apparatus, CLARENCE M. HALL, *Chairman.*

On Magazine Literature,
FREDERICK E. SEARS, *Chairman.*

On Current Events in Physics,
ROGER C. CHITTENDEN, *Chairman.*

On New Books, WILLIAM F. RICE, *Chairman.*

Election of New Members.

Election of Officers.

11: 30 *A. M.*

Address: *A. B. C. of Aeroplane Mechanics.* PROF. HARVEY N. DAVIS, of Harvard University.

12: 00 *M.*

Determination of Height of Aeroplanes. PROF. R. W. WILLSON, of Harvard University.

1.00 *P. M.*

Luncheon.

2.30 *P. M.*

Demonstration of New Lecture Table Apparatus by PROF. HARRY G. CHASE, of Tufts College.

(a) Zeiss Epidiascope (b) Gaede Pump (c) Apparatus for showing longitudinal vibration in steel wires.

Inspection of the Engineering and Physical Laboratories.

DEAN GARDINER C. ANTHONY will show apparatus for Pressure Recording Device for Punching Machinery.

PROF. E. H. ROCKWELL will show experiments on Strength of Materials.

PROF. CHARLES E. STEWART will show Methods of Ignition in Gas Engines and Methods of Testing Automobiles.

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Annual Meeting.

Morning Session, Robinson Hall.

President Greenlaw called for the annual report of the secretary which was read as follows:

Annual Report of the Secretary.

There have been three regular meetings as follows: Saturday, March 19, 1910, at Roxbury Latin School; May 21, 1910, at the Technical High School, Providence, R. I., and Saturday, Nov. 19, 1910, at the Jefferson Physical Laboratory, Harvard University, followed by the annual dinner in the evening at the City Club, Boston, Mass.

The men outside of our membership who have delivered lectures and addresses are, Prof. J. M. Jameson of Pratt Institute, N. Y., Prof. A. G. Webster of Clark University, Carl Barus, Ph.D., of Brown University, John L. Alger, Principal of State Normal School of Rhode Island, and Prof. G. W. Pierce of Harvard University.

All of our committees have worked well and have presented interesting and valuable reports. The Committee to Investigate the Teaching of Physics in Small High Schools, under the chairmanship of Mr. J. W. Hutchins, compiled and printed a very valuable report, nearly 600 copies of which have been distributed to high schools throughout New England.

Our membership is about the same as a year ago. Three active members and three associate members have resigned. Six active and five associate members have been elected. Two active members have been transferred to the associate list at their request. One active member has been placed on the honorary list.

Miss Minnie G. Farwell of Everett died in September, 1910.

Our present membership is seventy-seven (77) active and seventy-three (73) associate, three (3) honorary, a gain of five over last year. One new foreign correspondent has been appointed, Prof. E. Grimsehl, Direktor der Oberrealschule of Hamburg, Germany.

During the fall and winter of 1910-11, a course on the "Ionic Theory," under Prof. Kent of Boston University, was much enjoyed by some members of our association.

Respectfully submitted,

RALPH CHANNELL, Secretary.

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The Annual Report of the Treasurer was then read as follows:

Annual Report of the Treasurer.

RECEIPTS.

Cash on hand, March 19, 1910	$200.72
Dues for 1910	38.00
Dues for 1911	275.00
Subscriptions for School Science and Mathematics	78.95
Subscriptions for Technical World	6.00
Subscriptions for Scientific American and Supplement	41.40
Subscriptions for Popular Electricity	9.60
Subscriptions for Popular Mechanics	5.00
Subscriptions for National Geographical Magazine	2.00
Subscriptions for Electrician and Mechanic	.65
Subscriptions for Industrial Magazine	.50
Received for lunches	75.30
Total	$733.12

EXPENSES.

Roxbury meeting	$ 19.90
Lunches	80.75
Expenses and printing of report of Committee on Physics in Small High Schools	137.35
Printing, notices, manual, reports, etc	225.72
Expenses of secretary	30.00
Express, postage, etc.	26.42
Subscriptions to School Science and Mathematics	78.00
Subscriptions to Technical World	6.00
Subscriptions to Scientific American and Supplement	41.90
Subscriptions to Popular Electricity	7.80
Subscriptions to Popular Mechanics	5.00
Subscriptions to National Geographical Magazine	2.00
Subscriptions to Electrician and Mechanic	.65
Subscriptions to Industrial Magazine	.50
Cash on hand, March 25, 1911	71.13
Total	$733.12

Respectfully submitted,

PERCY S. BRAYTON, Treasurer.

I have examined the treasurer's report, and find it correct as above, and expenditures properly vouched for.

CLARENCE BOYLSTON, Auditor.

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After these reports were read and accepted the reports of the standing committees were given.

REPORTS OF STANDING COMMITTEES.

Report of Committee on New Apparatus.

Mr. Hall exhibited a model of a hot water heating and supply system.

This model is built of one-half inch and one-fourth inch whitewood, and stands thirty inches high, is twenty-four inches wide, representing a section of a house of three floors and basement.

In the basement is installed the tank, made of the familiar Apparatus A Boiler, to which is connected a heater coil run by the low form of Bunsen burner, and the cold and hot water pipes.

Brass one-eighth inch pipe is used and on the first floor is connected a radiator with valve.

On the second floor there is a miniature bathtub and a lavatory, both supplied with hot-water by small faucets made to operate easily.

On the top, or attic, floor is an expansion tank.

All the piping is brass, and the tanks, tub and lavatory are white enamel.

The model was homemade for the most part, the pipe-fitting being done by a regular gas-fitter.

The cost was about $5.00 complete.

A Tangent Galvanometer, made by Cambridge Botanical Supply Co., cost $3.50, was shown.

Useful for electromotive series of metals, simple voltaic cell, two fluid cell, resistance by substitution, and verifying the tangent law.

It is not sensitive enough for Wheatstone bridge work, as one can move the rider of a meter bridge, 20 cms., before getting an indication on the instrument, whereas, a movement of only one-half millimeter on same bridge, with D'Arsonval type, gave an easily visible deflection of the D'Arsonval galvanometer. The reason for testing this galvanometer was the desire to get one that had no filament to break; and the statement of one of the company that makes it, that it would show a mm. deflection, used on a slide wire bridge, if one moved the rider 1 mm. along the slide wire.

A further disadvantage of it is the long time taken for the needle to come to rest. It is far from being dead-beat.

This has been remedied in the instrument in my laboratory, by placing a small piece of soft iron wire under the needle and parallel to it when in the magnetic meridian.

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Mr. J. C. Packard reported on two electrical instruments, a portable voltmeter recording by 2 volts to 125 volts, and by .2 volts to 12.5 volts, and a portable ammeter reading to 25 amperes by amperes and to 5 amperes by 0.1 amperes. Made by L. E. Knott Co. Cost $7.00 each.

CLARENCE M. HALL, Chairman.

Report of Committee on Magazine Literature.

Cassiers' Magazine.

January, 1911. Wireless Communication from Air Ships, by A. Frederick Collins.

March, 1911. Oil Engines, by Percy R. Allen.

Century Magazine.

January, 1911. A Record Voyage in the Air, (from St. Louis to Quebec, made by Alan R. Hawley), by Augustus Post.

Electrical World.

January 12, 1911. (1) Automatic Control of Temperature, by A. A. Somerville. (2) A Simple Wireless Telephone, by John L. Hogan, Jr.

January 19, 1911. Envelope or Thin Plates for Storage Batteries, by Stockton H. Mortimer.

February 16, 1911. Measurements of Intrinsic Brightness by a New Method, by Herbert E. Ives and M. Luckiesh.

March 2, 1911. Design and Operation of Water Rheostats, by Francis H. Davies.

Popular Mechanics.

March, 1911. Inventions in Telephony and Telegraphy.

Popular Science Monthly.

February, 1911. The Dynamics of a Golf Ball, by Sir J. J. Thomson.

Science.

January 13, 1911. The Broader Aspects of Research in Terrestrial Magnetism, by Dr. L. A. Bauer. (An address before the American Association for the Advancement of Science.)

Scientific American.

December 24, 1910. (1) How High Altitudes are Made (in Aeroplanes). (2) Army Plan for Uncovering the Maine.

January 14, 1911. The New Storage Battery of Thomas A. Edison.

February 11, 1911. First Flight of an Aeroplane from the Water.

Several interesting biographical sketches: (1) A. A. Michelson (Jan. 7, 1911). (2) Sir James Dewar, F.R.S. (Feb 4, 1911). (3) John Ambrose Fleming (Feb. 11, 1911). (4) My Days with Edison, by Edward G. Achison (Feb. 11, 1911). (5) Sylvanus P. Thompson (Mar. 4, 1911).

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Scientific American Supplement.

January 7, 1911. What is the Ether, by Owen Ely.

January 21, 1911. Experimental Science Teaching (Some Applications of Marriotte's Bottle).

January 28, 1911. Science and Engineering, Comments by Sir J. J. Thomson.

February 4, 1911. Some Notes on Telephony; Facts and Principles Underlying Modern Practice, by H. Harrison.

February 11, 1911. The Manufacture and Industrial Application of Ozone (The Possibilities of a Remarkable Gas), by Dr. Oscar Linder.

February 18 and 25, 1911. Production of Low Temperature and Refrigeration, by L. Marchis.

March 14, 1911. Magnetic Alloys, by H. A. Knowlton, University of Utah.

March 18, 1911. (1) A New Wireless Transmitter (The Lorenz System Briefly Described). (2) The Physics of the Polar Seas.

School Science.

November, 1910. Three articles describing experiments with (a) the Brake, (b) Measuring Index of Refraction of a Glass Prism, (c) Measuring Centrifugal Force. Also descriptions of apparatus for determining Gas Laws.

January, 1911. An illustrated article on Bernoulte's Principle.

February, 1911. Some New Modifications of Old Experiments in Physics: (a) On a tuning fork making sympathetic vibrations, (b) On absorption of light, (c) On index of refraction, (d) A cheaply devised Atwood Machine.

March, 1911. The Humidity of the Air in School Rooms.

Technical World.

March, 1911. Many Talk on One Wire, by Rene Bache. (Brief Account of Work of Maj. Geo. O. Squier, U. S. A.)

World's Work.

January, 1911. The Children of the Gas Engine, by Robert Sloss.

FREDERICK E. SEARS, Chairman.

Report of Committee on Current Events in Physics.

The Consolidated Gas and Electric Light and Power Co., of Baltimore, is to install the largest storage battery in the world. It will have a capacity sufficient to take care of the peak load of the entire business section for half an hour, in case of accident to the main plant.

The Union Pacific has been testing Dr. Frederick Millener's invention in wireless telephony from moving trains, and expects to have it in actual operation within a year. Wireless waves fol-

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low the rails and work best in stormy weather. The ribs of an umbrella, held over the head, act well as receiving antennae and sounds are reproduced far better than an ordinary telephone receiver. A 5500 lb. truck has also been run around the Omaha shop yards by means of wireless waves.

An English R. R. is testing a German's invention of wireless telephoning from moving trains. A large wire frame is suspended below the car and the telephone current, passing through this, induces a current in a wire running along the ground.

The valleys of the Ghats, India, are to be damned to generate electrical power to be supplied principally to cotton mills in Bombay, 43 miles away.

According to papers before the British Institution of Electrical Engineers, the transmission of 200,000 volts by overhead wires may soon be feasible, because of improvements in design and research into materials for insulation, etc.

One section of the government railroads of Prussia is to be electrified with the "one-phase reversed current". In the new engines, the motors are to be set high from the ground, and the power is to be transmitted to the axles by cranks and rods as in steam-engines.

Successful tests have been made on an electrical device for preventing corrosion and pitting in metals, especially in boilers and metals immersed in sea-water. Dynamos can cheaply supply a weak current to the metal which will neutralize the galvanic action of the water.

The latest telephone cable between England and France contains induction coils every mile and a half. These seem to render speech clearer and to extend the talking radius.

An International Congress of the Applications of Electricity is to be held in Turin, Italy, in September. About the same time the whole Electrotechnical Commission is to meet at the same place.

France and England are far ahead of the United States in the matter of aeroplane engines. McCurdy was unable to keep his engine going long enough to cover the distance from Florida to Cuba, about 100 miles, Bellanger, in France, with a Gnome-Bleriot, recently covered 498 miles in an elapsed time of 7 hours and 14 minutes, stopping only for fuel and night.

Lieut. Bague recently made a flight of 140 miles over the Mediterranean, establishing a new record for over-sea flight.

Glen Curtiss' machine for alighting on and arising from the water, is fitted with a pontoon of waterproof canvas, 12 feet by 2 feet by 1 foot deep. It is rounded up at the ends and fastened to the bottom of the biplane.

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The Federation Aeronautique International has formulated a set of rules governing the issuing of airmen's licenses.

Most amateur aviators go to France and England for instruction because there are so many more in the work there, more machines are available and they can be delivered within two weeks of receiving an order. They have, also, finely equipped aerodomes for giving instruction.

The $10,000 prize for the Statue of Liberty flight during the Belmont Park meet may never be awarded, as all of the contestants seem to have failed in some one of the requirements.

Former seismographs have been very crude in recording the distance and direction of the origin of earthquakes. The new Galitzin seismograph is a vast improvement over the others. It consists of a pair of horizontal pendulums, perpendicular to one another so as to give the N-S and E-W components of the earth's motion. Two horse-shoe magnets, acting on a copper plate attached to the pendulum, makes it "dead-beat." The small pendulum motion is magnified by an ingenious galvanometer arrangement. The ratio of the amplitudes of the first impulse on the two instruments gives the azimuth of the epicentre of disturbance to about half a degree of arc. It also records the direction and force of the horizontal motion of the earth.

It has been found that with a row of two or more vertical antennae spaced at twice the wave length of the waves emitted, there is a maximum of strength propagated in a direction perpendicular to the plane of the antennae and zero in their plane. To change the direction of the wave then, one has simply to change the position of the antennae, though this necessitates the use of only short wave lengths. At the receiving station two sets of antennae may be set at right angles, and the direction of the wave determined from the proportional excitation of the two planes, and the antennae set for maximum reception. Such a system would prevent much of the present interference of messages, and be of great use to ships in a fog.

ROGER C. CHITTENDEN, Chairman.

REPORT OF BOOK COMMITTEE.

In connection with the subject of Aviation the following brief bibliography is given:

"Aerodynamics" by F. W. Lancaster. D. Van Nostrand, N. Y., 1908. 2 vol. pp. 900, 8 vo. $12.00 net. Scientific and mathematical.

"The Conquest of the Air" by Alphonse Beeget. G. P. Putnam's Sons, 1910. 8 vo. $3.50 net. Illustrated, descriptive, can be understood by a boy.

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"The Art of Aviation" by R. W. A. Brewer. McGraw-Hill Book Co., 1910. pp. 253, 8 vo. $3.50 net. Scientific, technical, illustrated.

"Vehicles of the Air" by Victor Longhead, Reilly and Britton, 1909. pp. 513, 8 vo. $2.50 net. Illustrated, descriptive, also working drawings and technical details.

"Aerial Navigation of Today" by C. C. Turner. Lippincott. pp. 327. 8 vo. $1.50 net. Descriptive, not very technical, in simple language.

"Conquest of the Air" by A. Lawrence Rotch. Moffat, Yard & Co., 1909. pp. 192, 16 mo. $1.00 net. Non-technical, descriptive, illustrated.

"The Boys' Book of Model Aeroplanes" by F. A. Collins. The Century Co., 1910. pp. 308, 12 mo. $1.20 net. No working drawings but complete descriptions.

WILLIAM F. RICE, Chairman.

After these reports had been presented the election of new members was held.

New Members.

The following were duly elected, having been nominated by the Executive Committee:

Active,

Arthur B. Stanley, High School, New Bedford, Mass.

Walter G. Whitman, Normal School, Salem, Mass.

Max Weiss, Rindge Manual Training School, Cambridge, Mass.

Roy F. Stevens, Dean Academy, Franklin, Mass.

Associate,

Amber L. Parlin, Central High School, Springfield, Mass.

Llewellyn R. Perkins, Dean Academy, Franklin, Mass.

S. E. Bailey, High School, Swampscott, Mass.

Next in order a vote was passed to hold a joint meeting with the New England Association of Chemistry Teachers; the subject to be, "The Scope and Contents of the Physical Sciences." Arrangements for the meetings were referred to the Executive Committee with power to act.

Election of Officers.

In each case first an informal ballot was taken and then a formal ballot with the following results:

President, C. S. Griswold, Groton School, Groton, Mass.

Vice-President, Fred H. Cowan, Girls' Latin School, Boston, Mass.

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Secretary, Alfred M. Butler, East Boston High School, East Boston, Mass.

Treasurer, Percy S. Brayton, Medford High School, Medford, Mass.

Executive Committee:

Fred R. Miller, English High School, Boston, Mass.

Frank M. Greenlaw, Cole's Laboratory, Newport, R. I.

Calvin H. Andrews, South High School, Worcester, Mass.

Further business was postponed until the afternoon session.

Prof. Harvey N. Davis, of Harvard University, spoke on, The A. B. C. of Aeroplane Mechanics.

THE A. B. C. OF AEROPLANE MECHANICS.

The rapid development of aviation within ten years from a dream to an accomplished fact is one of the most spectacular events in the history of applied science. As a result, one finds today a widespread and on the whole, most intelligent interest in aviation among all classes and ages in the community. This offers a valuable opportunity to teachers of physics, for if they will inform themselves on even the simplest of the mechanical aspects of aeroplanes they will find a wealth of interesting material for the enlivenment of instruction in mechanics. For those who read German, an admirable source of information for this purpose is a ten page article by H. Jansen on page 329 of the 1910 volume of the "Zeitschrift für den Physikalischen und Chemischen Unterricht." Another useful paper, by Major Squier of the U. S. Signal Corps, was presented to the American Society of Mechanical Engineers in December, 1908, and can be obtained for a nominal price from the secretary. Books on the subject are numerous, but are usually either too technical or not technical at all. To such as are without access to any of these sources, the following brief summary of some very elementary material may be useful. It will be presented under the four heads of support and propulsion, fore and aft stability and control, lateral stability and control, and horizontal steering. Some of the fundamental theorems of mechanics of which the aeroplane affords illustrations are mentioned in italics.

1. Support and propulsion.

The simplest possible areoplane is a kite. If a kite is presented to the wind at an inclination that is neither horizontal nor vertical, the air, in order to get by, must be somewhat diverted downward as in Figure 1, and will therefore be somewhat compressed below the kite, so that the pressure on its lower face will be greater than the average pressure in the neighborhood. Above and behind the kite there will be more than the normal

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amount of room available for the passing air, and therefore expansion and diminished pressure. Each square inch of the kite's surface has, therefore, unequal pressures on its two faces, and is urged upward by a force perpendicular to them; there is also a small tangential force toward the rear due to friction between the surfaces and the passing current of air. All of the forces perpendicular to the kite have at any instant a resultant, also perpendicular to the kite, acting at a perfectly definite point in its surface which may be called the center of pressure (*composition of parallel forces*). Similarly, all the tangential forces have a resultant which can be thought of as acting at the same point (*a force can be displaced along its line of action*). The whole effect of the air on the kite is equivalent to a single force at the center of pressure pointing somewhat behind the normal to the surface at that point (*composition of concurrent forces*). This is the force R in figure 2. If the center of pressure happens to coincide with the center of gravity, as in figure 3, the weight of the kite, W, acting at the same point, gives, with R, a resultant pointing still more behind the normal. If another force, S, equal and opposite to this resultant, can be applied at this point, the kite will be in equilibrium (*equilibrium of a particle*). Such a force is exerted by the kite string. If the kite string is cut away and an engine installed whose weight is equal to the downward component of the force S, and whose "drive" is equal to the forward component of the force S (*resolution of forces*), the kite becomes an aeroplane able to hold its own against the wind that supported the kite, or to make progress against a wind of less velocity.

If the center of pressure does not coincide with the center of gravity, as in figure 4, the force S should be applied at a point different from either the center of pressure or the center of gravity (*three forces, to hold a rigid body in equilibrium, must be concurrent*).

So much for the qualitative side of the case. To get a quantitative idea of the magnitude of the forces involved, let us regard the force R exerted by the passing air on the kite as the equal and opposite counterpart of the force exerted by the kite on the passing air (*action and reaction are equal*). The effect of the reaction on the air is to change its momentum. The fundamental equation is

$$P\,t = M\,\Delta V,$$

or

$$P = \frac{M}{t}\Delta V.$$

In this equation M/t is the mass of air affected in each second. ΔV represents the average change in its velocity during the

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second. This change may be in part a change in the speed of the air affected, but it is much more a change in the direction of its

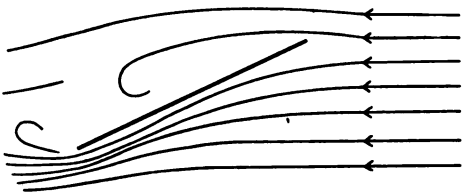

Figure 1

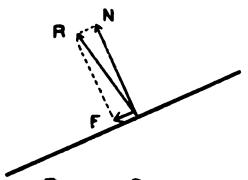

Figure 2

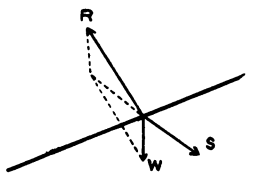

Figure 3

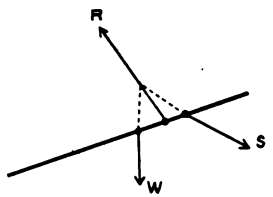

Figure 4

motion. It is difficult to get an exact value for ΔV by any elementary reasoning, but it is both reasonable and experimentally

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verifiable that it is proportional to the original velocity, V, of the wind itself.

$$\Delta V = k_1 V.$$

The mass of air affected in each second is also obviously proportional to V. It is also proportional to the density of the air, d, and (within the limits of size common in aeroplanes) to the area, A, of the supporting surface.

$$\frac{M}{t} = k_2 dVA.$$

Therefore

$$R = kdV^2A.$$

The value of the factor of proportionality, k, in this equation depends on a number of things. Among them is the shape of the plane. If it is a rectangle and is presented end forward, more air will spill around its sides than if presented long side forward, and k will be larger in the latter case. This is one advantage which Hargrave or box kites have over the older form. Another consideration is the fore and aft curvature of the surface It is found that k is larger if the surface is slightly concave downward or shaped like an elongated S. Another most important consideration is the angle, θ, which the chord of the surface makes with the horizontal, the so-called angle of presentation. The greater this angle, the greater the value of k—but the exact form of the relation is still uncertain. The simplest possible theory, proposed by Newton, leads to the law

$$k_\theta = k_{90} \sin^2 \theta$$

but experiments do not verify this. Many other expressions involving θ have been suggested, of which sin θ is probably as good as any for practical use; a list of them can be found in Jansen's paper; all that is necessary for the present purpose is the fact that k increases with θ.

In any case, for a given surface presented at a given angle in air of given density, R varies as the product V^2A. The horizontal component of R is called the head resistance and varies as V^2A. The vertical component of R is called the lift and it also varies as V^2A. The first is equal and opposite to the propelling force which the engine must exert. The latter is equal and opposite to the maximum allowable total weight.

Two conclusions can be drawn:—

A. The speed law;—the force necessary to propel a given aeroplane with supporting surfaces of invariable size, at different speeds, varies as the square of the speed. Therefore the horsepower required varies as the cube of the speed (*definitions of work and power*). It required 20 H.P. to drive the 1905 experi-

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mental Wright machine at a speed of 38 miles an hour. According to the speed law, it would have taken 160 H.P. to drive it at the 76 miles an hour which will be required of a successful 1911 racing machine. On the other hand, if the 925 pounds of the 1905 model could just be supported at the slower speed, 7400 pounds could be supported at the higher speed, which would leave over three tons of extra lift available for supporting the larger engine.

B. The law of reefing:—If an aeroplane of invariable weight is to be driven at various speeds, with bare support at each speed, the exposed area of its wings should be progressively diminished as the speed increases, in such a way as to keep the product V^2A constant. In other words, its wings should be reefed like the sails of a boat. It will be easy for the reader to verify for himself that under these circumstances the force necessary to keep such an aeroplane in motion is independent of the speed, while the horsepower required increases only as the first power of the speed. If the wings of the 1905 Wright machine could have been reefed to one quarter of their original size (and if the head resistance of the framework and operator could have been decreased in the same proportion) it could have been driven at 76 miles an hour with only 40 H.P. This is very nearly what was done in designing the "Baby Wright" racer that was so unfortunately wrecked on the morning of the Gordon Bennet Cup Race last October. Its wing spread was somewhat more than a quarter of that of the 1905 model because of the increased weight of the engine and the impossibility of reefing the operator's body, but its horsepower was only about 60, and yet it is believed to have reached 70 miles an hour.

The realization in practice of this principle of reefing, while a machine is in the air, is probably the most important step soon to be taken in the development of the aeroplane.

2. Fore and aft stability.

This can be secured either through the conscious skill of the operator or, in part at least, automatically. It can be secured automatically by mounting a small fixed horizontal surface at some distance from the main planes. This surface cannot be in front as the equilibrium in the horizontal position in the face of the onrushing current of air would be unstable. The principle is that of a weather cock. The early Wright machines had no horizontal tail but depended entirely on the skill of the operator. Their new models agree with most other makes of aeroplanes in having one.

For the conscious control of fore and aft stability and for steering the aeroplane up and down a movable horizontal rudder is provided. If this is in front and is so tipped as to point the

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machine upward, not only is the lift of the main surfaces increased so as to lift the machine, but the rudder adds some lift of its own. If it is behind and is so tipped as to point the machine upward, its own small effect is wholly downward, and the rise of the machine is therefore less rapid (*theorem of the motion of the center of mass of a system*). It is, therefore, preferable to have the elevator in front, but, for structural reasons, rear elevators are very often used.

3. Lateral stability.

Here again either conscious or automatic control may be sought, but the automatic lateral stability so far attainable is much less valuable than in the fore and aft case. The only simple principle of any importance is one embodied in a few biplanes and in most monoplanes. It is very noticeable, for example in the Antoinette monoplane, the wings being several feet higher at their tips than at their points of attachment, forming a very blunt V. The effect of this in automatically preserving lateral equilibrium can be observed by anyone who will bend a 3 x 5 card through its center parallel to its shorter edge until its halves make an angle of about 120° with each other, and will then drop it from various initial orientations. The mechanical principle in action is the principle of moments, both the lever arm and the air resistance itself being greater on the side that is too low.

Conscious lateral control is secured by some device that enables the lift of each wing to be varied independently. In the Wright machine this is accomplished by warping the whole of each wingtip, so as to raise or lower its outer rear corner. This alters the average angle of presentation of each wing in such a way as to increase the lift on the low side and decrease it on the high side. One incidental effect is that the head resistance is also increased on the low side and decreased on the high side and this would tend to swing the machine off its course if the rudder were not so connected as to be automatically turned in the compensating direction at the same time. This is the substance of the famous Wright patent.

Other similar devices are used by other makers. In the Bleriot and Antoinette monoplanes, for instance, each wing is rigid, but can be slightly rotated as a whole around a horizontal axis so as to change its lift. In the Farman and some of the Curtiss models most of each wing is rigid and immovable, but there is a small tip, hinged to the rest, which can be moved. In other Curtiss models, and in Burgess-Curtis machines, small movable wings or ailerons are mounted between the main surfaces near their tips. In the Pfitzner monoplane, not yet a commercial success, arrangements are provided for increasing the lift of the

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low side wing by actually changing its exposed area; this device is a promising forerunner of true reefing.

4. Horizontal steering.

It is easy to change the orientation of an aeroplane in motion by turning a vertical rudder, but this is not enough to make an aeroplane negotiate a curve successfully. Something analogous to the keel of a boat must be provided to exert on the aeroplane a sidewise force of sufficient magnitude to pull its center of mass around the curve (*centripetal force*). This can be accomplished in either of two ways. (a) In the Voisin biplanes (and in some others) large vertical surfaces between the main planes (as in a box kite) give a sidewise thrust whenever the head of the machine is pointed to one side. (b) The mechanism for lateral control can be consciously used by the operator to bank the whole machine like a railroad train on a curve, until the normal pressure on the under side of the main supporting surfaces yields a horizontal component large enough to produce the desired centripetal acceleration. This is by far the commoner practice, and it is the basis of some of the most beautiful aerial manoeuvers that are executed, such as the famous *vol planes* of the Wright flyers. Many interesting problems can be based on the frequently published particulars of these feats. For example, Brookins is said to have made a complete circle in six seconds in a machine that must have been going at about 40 miles an hour; at what angle did he probably bank his planes?

In the future of aeroplaning there are many problems that have scientific aspects almost as simple as those already described. The most important of these is probably the realization of the principle of reefing. Next is the attainment of a much greater measure of automatic lateral stability. Next is the provision of effective "air brakes" for producing powerful retarding forces while an aeroplane is still in flight so that it can land on the roof of a modern office building. Powerful accelerating forces are also needed to enable it to start safely from such perches; perhaps these can be provided for by temporary reefing. And if, in addition to these, someone can provide for such a division of the power plant as will enable one half of it to drive the aeroplane at half its normal speed under sufficient sail area while the other half of the power plant is being adjusted in mid-air, the day of the aeroplane will have come for good.

During the presentation of this paper a number of slides were shown illustrating most of the devices mentioned.

Prof. Robert W. Willson, of Harvard University, talked about Methods used at Squantum to Determine Heights of Aeroplanes.

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Prof. Wilson said in part:

The preparations for measuring altitudes at the Harvard-Boston Aviation meet were made with the understanding that the aviators would be willing to arrange their flights in such a manner that they would rise in spirals above the field so as to cross and re-cross a given line at each circuit and attempt to reach a maximum altitude at a point above the line not far from the starting point of the course; and that the altitude reached in this plane should be taken as the height of record. It was also agreed that but one competitor at a time should contend for the altitude record. A second more general method was subsequently added as a check.

First Method:—

A "field base" of 5,000 feet was measured approximately north and south across the field. The north and south direction was chosen in order that the line of sight from each station might be as far as possible from the sun at that time of day when the conditions are favorable for flight. At each end of the base line were sextants provided with extensions of both horizon glass and index glass for convenience in finding the aeroplanes and making an approximate setting with the naked eye as the time of transit approached, to facilitate accurate observations with the telescope at the critical moment. A "quick slow motion" replaced the clamp and tangent screw. These modifications were successful in enabling observations to be made with ease and certainty. The point determined was the center of the aviator's body or when this was not distinctly visible, the estimated center of the wings of the aeroplane. The sextants were mounted on stands, the plane being made vertical by a level attached for that purpose. The reflected image of the aeroplane was brought to coincide with a target placed at a sufficient distance in the line of the base and in the same horizontal plane with the sextant telescope. Sextants were chosen because the angles could be measured up to and beyond the zenith without change of position of the observer's eye.

The sextant stations were connected with each other through a telephone line passing through a central station adjoining the room of the contest committee at the center of the grandstand.

The recorder at each station immediately reported the measured angle to the central station where a graphic table or chart was used to determine the altitude at once, and it would have been possible to announce the result within half a minute of each crossing of the line.

Second Method:—

An east and west base line was chosen also, about three miles

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south of the center of the aviation field. One station was on Forbes Hill in Quincy at a height of 128 feet above the center of the field, the second in Milton at a height of 71 feet. The length of this line was 6236 feet. The instruments used were a special theodolite by E. L. Berger and a Buff & Buff mining transit. These stations were also connected with the central station by "phone."

By combination of the two methods observation could be taken and altitudes computed at intervals of about 45 seconds, in some cases 30 seconds. The last method seems preferable to any that requires the aviator to attain his maximum height at a given point or line.

At the central station on the field with a head piece carrying at one ear the telephone of the sextant circuit and at the other the telephone from the distant base, the two transmitters side by side in front of him, the chief operator held command of the whole system and could accomplish more than was considered necessary to provide for.

By using the transits on one aeroplane and the sextants on another accurate records of height of both were determined simultaneously.

To illustrate his talk, Professor Willson used slides of sextants showing modifications and graphs of different flights, showing how closely the transits checked with the sextants.

Baroscopes were carried by some of the aviators, but were unreliable if used alone. Both Graham-White and Brookins carried them on September 8. A comparison of the two immediately after the descent showed that the height reached by Graham-White was about 350 feet less, so he was credited with 3500 feet. The transits were fully occupied by the flight of Brookins and without the baroscopes it would have been difficult or impossible to determine the relative heights as the Bleriot went so far off the course that it could not be observed with the sextants.

In spite of limited time for preparation, and total lack of practice in advance of actual trials, both methods used gave satisfactory results and it is a source of regret that no great heights were reached during the meet to put them to a more severe test.

At the close of Prof. Willson's talk the meeting was adjourned until 2.30 p. m.

Luncheon was served at 1.00 p. m. Afterwards many took the opportunity to visit the Museum and other buildings of the college.

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AFTERNOON SESSION.

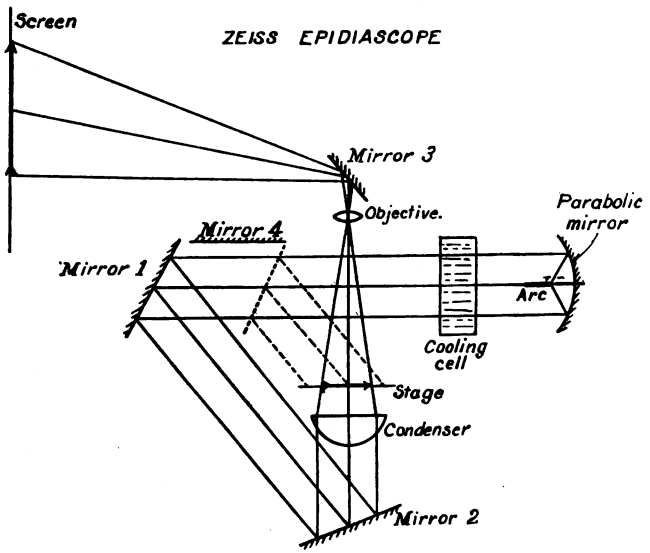
Meeting called to order by new president, Mr. C. S. Griswold.

Executive Committee was balloted for with results as recorded in list of officers.

The Secretary was instructed to communicate to the President and Trustees of Tufts College the sincere appreciation of the hospitality shown the association.

The secretary announced that Dr. Svante Arrhenius had accepted the joint invitation of the Physics and Chemistry Associations to a banquet to him. The date probably to be April 28.

Then the Epidiascope was shown by Prof. Harry G. Chase of Tufts. A diagram of the machine was first shown on the screen. Then many different objects were illustrated by means of the machine. Flowers, a watch, fossils, line drawings, postcards, an ammeter showing the current strength in use, and fields of magnets as shown by iron filings maps were thrown on the screen. The final object was a large salamander in its vessel of water. Machine costs $500.



Prof. Chase showed the Gaeda pump in operation and demonstrated the machine with tubes exhausted during the experiment.

The last experiment was a simple one to show longitudinal vibration in a wire. Small paper riders were placed on wire and wire set in vibration by being stroked lengthwise with a resined cloth. The riders gathered at equal intervals showing nodes clearly.

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Dean Gardiner C. Anthony now invited members to visit shops and spoke of punching machine device for recording pressure used.

Pressure Recording Indicator for Punching Machinery.

This is a device to be used in connection with a hydraulic indicator for making records of the stresses due to punching metals and especially boiler plate. It was devised to work under the normal conditions of the boiler shop punch. By this means indicator diagrams are obtained as readily, and in much the same manner, as those taken from a steam engine during test.

It was thought to obtain some valuable records connecting the flow of metals during the process of punching, but as yet a sufficient number of tests have not been made to demonstrate the efficiency of the device in this respect.

The mechanism will be applied to a 60,000 lb. Olsen testing machine when exhibited at the meeting of the Society.

As a piece of laboratory apparatus it serves admirably for obtaining data relating to the following: the maximum pressures for which punching machines should be designed, the point of maximum stress in the punching of plates and other material, the effect on the maximum stress by increasing the clearance between punch and die, the advantages to be derived from the use of shearing punches, and finally the effect of time on the flow of metal in punching.

In the shop the punching machine and indicators were shown in action. Prof. E. H. Rockwell exhibited a machine for testing the strength of concrete beams. Prof. Charles E. Stewart demonstrated methods of ignition in gas engines and methods of testing automobiles.

On exhibition about the shop were the following devices:

Bosch Low Tension Magneto.

Bosch High Tension Magneto.

Simsus High Tension Magneto (fixed spark).

K. W. Low Tension Magneto.

A 30 H. P. auto engine was shown equipped with 3 spark system, magneto, ordinary 4-unit coil and the Atwater Kent non-vibrating system.

A marine motor was also exhibited. The Delco Igniting system and Connecticut High Tension Magneto, Transformer Type, were shown.

RALPH CHANNELL, Secretary.

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PROGRAM OF

THE FIFTY-NINTH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, June 3d, 1911

at Groton School, Groton, Mass.

11:00 *A. M.*

Address of welcome by Rev. Sherrard Billings, Acting Head Master of Groton School.

Business Meeting.

Report of Standing Committees.

Committee on New Apparatus. Homer LeSourd, Chairman.

Committee on Magazine Literature. Francis R. Hathaway, Chairman.

Committee on Current Events in Physics. Francis E. Mason, Chairman.

Election of New Members.

11:45 *A. M.*

Demonstration of Chladni Figures. Mr. Roswell Parish, Mechanic Arts High School, Boston.

Cathedral Bells and Bell Pealing. Mr. S. Warren Sturgis, Groton School.

The Physics of the Pipe Organ. Mr. H. L. Crane, Groton School.

12:30 *A. M.*

Demonstration of Bell Pealing in the Tower by the School Bell Crew, followed by an illustration of Mr. Crane's talk on the Organ, closing with short Organ Recital, introducing Cornet and Violin.

1:30 *P. M.* Lunch.

2:30 *P. M.*

Address: *Interference and Resonance in Architectural Acoustics.* Mr. Wallace C. Sabine, Dean of the Graduate School of Applied Science, Cambridge, Mass.

The Mechanism of the Ear. Mr. John C. Packard, Brookline High School, Brookline, Mass.

The demonstration of Bell-ringing will consist of ringing a "Touch of Grandsire Doubles" on the hand bells; *i. e.*, 120 changes on five bells; followed by ringing the tower bells in the above mentioned and other changes.

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The Fifty-Ninth Meeting.

The meeting was called to order by President Griswold, who in a few remarks introduced the Reverend Sherrard Billings, Acting Head Master of Groton School, in the absence of the Reverend Dr. Peabody.

Dr. Billings in his address of welcome said that hitherto science had received little recognition in the school curriculum, which has been largely determined by the college requirements. The change in requirements recently announced offered great opportunity for the curriculum to be laid out along different lines, better adapted to the needs of the school, and in this new outline, science would undoubtedly be given great recognition. Speaking for the faculty he said that they considered it an honor that one of their number had been chosen as our President, and that they were glad to see the members of the Association and to extend to us the freedom of the school during our visit.

Mr. Homer W. LeSourd, Chairman of the New Apparatus Committee, then reported as follows:

REPORT OF COMMITTEE ON NEW APPARATUS.

There is a noticeable dearth of lecture table apparatus for illustrating sound. Many teachers omit the subject altogether for lack of time. A few well-selected experiments in sound, however, serve to effectively introduce the subject of light, since sound waves transmitted by a material medium are more easily understood by students than are light waves and ether. Wave motion, both longitudinal and transverse, may be demonstrated by the Ames and Bliss wave apparatus which consists of a steel ribbon 13 feet long to which are attached at regular intervals cross-rods having a ball at each end. One end of the ribbon is fastened to the ceiling. Longitudinal wave motion is shown by giving an upward stroke to one of the balls on the lowest cross-rod. The apparatus gives a somewhat better representation of transverse waves. In this case the lowest rod is given a torsional motion and the wave, when viewed from a distance of ten feet or more, appears to be a transverse one. On reaching the upper end of the ribbon the wave is reflected and gives rise to nodes and loops due to the combination of advancing and returning waves. The apparatus costs about ten dollars.

Gamut Bells consist of two octaves of flat metal rods so mounted as to produce clear, sustained tones. For use in a large class room they are more effective than tuning forks. Pitch, vibration ratios, harmony, discord and beats can be discussed by the aid of this apparatus. The price of the set is ten dollars.

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The range of audibility for the human ear is in general from 18,000 to 30,000 vibrations per second. Interesting tests may be made on members of a class, regarding their ability to hear low tones by setting a steele rod to vibrating in a vise and gradually lengthening this until no tone is recognized. The upper limit of audibility may be tested by a series of glass rods of heavy thermometer tubing cut to different lengths and strung by thread between two parallel strips of wood. When these are struck from longest to shortest in succession with a small wooden mallet it will be found that for different persons the limit of audibility differs greatly. With this Apparatus there is no satisfactory method of determining the vibration frequency. Galton's Whistle is somewhat more satisfactory. This is a small metal whistle, the piston of which is threaded and graduated like a micrometer gauge. The length of the air column which gives the highest audible tone can thus be measured and from this the wave length and vibration frequency of the tone can be computed. The Galton Whistle costs eight dollars. The Wave Apparatus, Gamut Bells and Galton Whistle came from the Central Scientific Company. H. W. LeSourd, Chairman.

The report of the Committee on Magazine Literature follows; Francis R. Hathaway, Chairman:

REPORT OF COMMITTEE ON MAGAZINE LITERATURE.

Electrical World.

March 16, 1911—Arc Lamp Electrodes. Their Composition, Method of Manufacture, and Impregnation for Various Classes of Service. (A. Mahlke.)

April 6, 1911—Electrolytic Corrosion of Iron in Concrete—an editorial on a paper, by Prof. Charles F. Burgess.

Harper's Weekly.

May 20, 1911—The Story of Silk. (Thaddeus S. Dayton.)

Popular Electricity.

May, 1911—Madam Curie the Woman. (Laura Crozer.) Five Epoch-Making Electrical Inventions.—II. The Electrical Railway. (Elmer E. Burns.) The Making of Moving Pictures. A. Personal Appreciation of Thomas A. Edison. (Joseph E. Hinds.) History of the Wireless Telephone. (Lindley Pyle, A.M.) The Mercury Vapor Lamp. (Albert Walton.)

June, 1911.—Tesla and His Wireless Age. (Arthur B. Reve.) Five Epoch-Making Inventions.—III. The Telephone. (Elmer E. Burns.) How Radium is Made and Kept. (Arthur B. Reeve.) Copper from Ore to Pole.

Popular Mechanics.

May, 1911—Nongyroscopic Aeroplane Motor to Increase Stability. (J. Q. Roberts.) From Torch to Tungsten in Light's History. The Kingdom of Dust. (J. Gordon Ogden, Ph.D.)

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June, 1911—How the Colors of Nature are Reproduced in Moving Pictures. (J. Q. Roberts.) Explosions and Explosives. (Hudson Maxim.)

Popular Science Monthly.

April, 1911—The Genesis of the Law of Gravity. (Prof. John C. Shedd.)

Science.

March 17, 1911—Octave Chanute. (James Means.)

April 28, 1911—Interesting description of a mercury still, an adaption of the mercury arc lamp. (Charles T. Knipp, Un. of Ill.)

May 5, 1911—Some Recent Advances in Fluorescence and Phosphorescence. (Prof. E. L. Nichols.)

May 19, 1911—A Communication of Prof. Edwin H. Hall on Metals, wet, describing experiments on this subject.

Scientific American.

March 18, 1911—Dedication of the Roosevelt Dam. (C. J. Blanchard.) The One-Piece House—Construction of Concrete Houses. (J. P. H. Perry.)

April 15, 1911—Good Coal and Poor—Purchase of coal on the basis of its heating value. (J. A. Holmes.) Lamps of Today, some recent improvements in Artificial Light Sources. (Joseph B. Baker.) Light and Power on the Farm—Independent electric generating plants. (Putnam A. Bates.) Inventing the Light of the Future—The Eye as the Ultimate Judge.

April 22, 1911—The New Aeroplane Passenger-Carrying Record.

May 13, 1911—The Dirigible of Today—a Review of French, English, and German Airships.

Several Biographical Sketches: (1) Jacobus Henricus Van't Hoff (Mar. 18, 1911); Edouard Branly (April 1, 1911); William Ostwald (April 29, 1911); Dr. Charles P. Steinmitz (May 6, 1911); Octave Chanute (May 13, 1911); Some Famous American and European Aviators and Designers (May 13, 1911).

Scientific American Supplement.

April 15, 1911—Working Distances of Wireless Stations. (W. C. Getz.)

May 6, 1911—New Researches in Quartz Lamps (description of the Westinghouse—silica mercury vapor lamp).

School Science.

April, 1911—Testing the Results of Science Teaching, by Edward L. Thorndike of Teachers' College, New York City.

May, 1911—A Wall Form of Bending Apparatus.

June, 1911—The A. B. C. of Aeroplane Mechanics. (Harvy N. Davis, Harvard University.) Simple Demonstration of Color Mixtures. (H. Tecke.) A Simple Reflecting Galvanometer. (J.

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M. Arthur.) An Important Scientific Discovery, *i.e.*, isolation of the atmospheric ion.) (Prof. Robert A. Millikan.)

Technical World.

May, 1911—The World's Debt to Wireless. (Charles Frederick Carter.)

June 1911—Household Electricity Meter. (Joseph B. Baker.)

The report of the Committee on Current Events in Physics follows; Francis E. Mason, Chairman:

REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

An experimental gasoline electric car has been built for the Buffalo, Rochester and Pittsburgh R. R. It is equipped with a gasoline engine and a generator which drives the regular motors of the car. Experiments show that the car runs economically. It carries enough gasoline to run 200 miles.

An electrolytic sewage purification plant is in operation in a Western city. Iron electrodes immersed in tanks containing the sewage become covered with oxygen, which destroys the organic matter and bacteria. The cost of operation is especially low.

Autogenous welding, or the process of joining metals without solder has made a great boom in the manufacture of calcium carbide. The oxacetylene blow-pipe has made this possible. This process is displacing electro-welding. The oxacetylene blow-pipe has also been used in several instances to cut through the tangled girders in the debris of fires. They can be cut in several pieces in a very short time, which greatly facilitates the removal of the ruins.

At the University of Utrecht a sound-proof room 7 1-2 feet square has been constructed. As it is located in the top story of the building it can be ventilated and supplied with sunlight. Its walls are composed of half a dozen layers of different absorbing substances with air spaces. It is said that persons on entering the room experience peculiar sensations in the ears.

At the Polytechnic School of Rio de Janeiro an interesting pyrometer has been invented. Two large whistles like organ pipes are used; one is made of Platinum or Silundum and reaches through the wall of the furnace and into the fire. The pipes are blown by twin mouthpieces and are adjusted to sound in unison when the furnace is at the right temperature. With a person of reasonable musical gifts, the pyrometer is said to be perfectly successful.

Experiments in Budapest have shown that the spark rays made by the incandescent particles thrown off from iron and steel when on the emery wheel afford a method of testing the composition of the metals. The various kinds each give off sparks which are characteristic in shape and color.

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For estimation of the loss of weight of the radio-active substances, the ordinary chemical balance is useless. Steets and Grant have devised a balance with which a loss of weight as mall as one-ten-thousandth of a milligram can be accurately determined. This balance has been employed by Ramsey with great success. The description of the balance and the method of its operation are too complicated to be described here, but the June number of *School Science and Mathematics* has a reprint of the description given in the *Scientific American.*

Cement sidewalks grow; they also tend to shed their top coats. Both these phenomena have been explained by Prof. A. H. White of the University of Michigan, who says that cement once expanded by moisture never contracts quite to its former size; hence the growth. The peeling of the top coat is explained as follows: the upper coat contains much cement and little sand, and therefore expands more than the rest of the walk, outgrowing the under layers.

Natural gas issuing from crevices in the ground has been burning since the memory of man in the so-called "fire country," twenty miles from Chittagong, British India. Steps are being taken to extinguish the fires, control the gas and pipe to Chittagong, where it will be used for lighting and fuel.

Gasoline solidified into a stiff white jelly by adding a small per cent. of steatite and alcohol is being successfully used in the motors of automobiles. An economy of 30 per cent. is claimed by the inventor.

Wireless light is the latest possibility of the scientific world according to Thorne Baker. Recent experiments on the neon light suggest enormous possibilities for future lighting. The neon light is simply a long vacuum tube into which a little neon is introduced. When a current of sufficient voltage is passed through, the tube glows with a rich reddish light. The candle power per watt is very high. Recently it has been discovered that neon tubes will glow when near wireless-sending apparatus. Perhaps the homes of the city of the future will be equipped with neon tubes to be lighted by a central wireless plant to furnish the electric waves.

Copper may be hardened by a mixture of alum and arsenic. The alum-arsenic mixture is stirred into the molten metal for about five minutes before pouring.

Following these reports the resignation of Mr. J. B. G. Welch of Sanborn Seminary was presented and accepted, and the application of Mr. Edward Sturtevant, St. George's School, Newport, R. I., for active membership, presented. Mr. Sturtevant was unanimously elected to membership.

Owing to the fact that only thirteen indicated their intention

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to take the Course on Heat, offered by the University Extension Department of Harvard, where thirty were needed to make the Course possible, the idea of such a course had to be abandoned.

Mr. S. Warren Sturgis then presented the following talk on

CATHEDRAL BELLS AND BELL PEALING.

In this paper I shall touch upon the construction of the individual bell and the mechanical methods of ringing it; I shall then discuss very briefly the system of "scientific change rings," which is extensively practised in the English churches and which we bell-enthusiasts hope may some day become popular in our own country.

The history of bells is an interesting topic. Their origin is lost in the dim distance of antiquity; but they probably passed into the service of the Church from their use by the Romans as a means of summons to the public baths, as a feature of solemn processions, etc. By the year 400 A. D., there are records of their use in churches and monasteries. These bells were generally small and of widely varying shapes; all however answering the general definition of a bell as "an open percussion instrument so constructed as to yield one dominant note."

About the middle of the 16th century continued experiments had already evolved what has remained as approximately the ideal form of bell to this day. The names of Vander Zheyn and Hemony in Holland are famous as the perfectors of this modern type.

A good bell gives out one dominant tone known as the *consonant* or *key note*, which is composed, however, of at least three definite tones. These can be tested by striking the bell at different points. Strike on the curve of the top and you get the octave above the consonant; one quarter down from the top and you get the fifth or "quint," still lower and you get the third or "tierce." These factors and consequently the key note or pitch of the whole bell can be slightly altered after casting by filing the bell at certain points, but so much is a "maiden" bell prized (*i. e.*, one which has not been touched after casting) that many bells were in former times left a little false rather than submit them to a process of tuning.

But besides the key note of his bell, the designer must reckon with the overtones and the deep hum note which are always present; for according as these are in mutual harmony or discord is determined the musical quality of the bell, though this depends also on the fineness and mixture of the metal, on the casting and on the proportion of metal to the calibre of the bell. It is in the intricacies of this branch of the subject that the English bell-makers are unequalled.

Of individual bells, I might mention a few which are world-re-

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nowned. The largest in existence, the great bell at Moscow, was cast in 1733 but was cracked in the foundry and never rung. It is nineteen feet high, twenty feet in diameter and weighs two hundred twenty tons. The largest bell in use is also in Moscow and weighs one hundred twenty-eight tons. The heavy bell at Notre Dame weighs seventeen tons and that at St. Paul's, London, five tons.

A bell may be sounded in a number of ways. The tongue may be pulled against its inner surface by a cord; an outside hammer may be swung against it or dropped upon it by a system of levers regulated by clock work, or the bell itself may be swung so that the tongue is thrown across the mouth of the bell by centrifugal force. Let me say here that this third method is the only one which really utilizes the principles of bell design. For the flaring curve of the bell mouth is scientifically designed so as to throw the vibrations to the farthest possible distance. Obviously then, when a bell which hangs mouth downward a few feet above the belfry floor, is struck with a hammer, the musical and carrying effects are both seriously impaired.

Turning now to sets of bells, the most elaborate effects are obtained in the so-called "carillons" of Belgium. These consist of thirty to sixty bells, played from a key-board which allows a mechanically raised hammer to fall upon the bell. Special music is composed for these carillons and expert musicians devote themselves to playing them.

England however is pre-eminently the centre and the home of the most scientific bell ringing. Over two thousand sets of bells are hung in churches there, and most of them regularly rung at least once a week for Sunday services. And practically all this ringing is done on sets of eight to twelve bells, each bell being handled by a separate ringer. The bell is rigidly bolted to a heavy wooden beam or headstock. At one end of this is attached a large wooden wheel, and around the grooved flange of this well passes a rope by which the bell is controlled. When a bell has been swung farther and farther till it is balanced mouth upwards, it is said to be "set" and may then be rung stroke by stroke, faster or slower, as the ringer wishes, for a very slight pull exerted as the bell begins to swing will carry it the whole way around, causing the heavy tongue to swing across and strike as the bell's revolution becomes slower. It is in the exertion of the exact amount of force necessary to "set" the bell (*i.e.*, to balance it upside down) that the ringer's control of his bell consists. Should the pull be a trifle too slight, the bell falls back too quickly; should it be a little too great, the ringer exhausts himself by having to throw his weight upon the rope to keep the bell from swinging over too far.

Suppose now a set of ringers have learned to control their

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bells. They naturally begin by ringing them in what is known as "rounds," that is in regular succession from the "Treble" or highest toned bell to the "Tenor" or deepest toned bell. To break the monotony, a slight pause is generally made after every second round; so that with eight bells the effect is a repeated series of sixteen strokes.

But mere rounds, or the repetition of a few stereotyped variations in the order of the bells soon becomes wearisome, and this brings us to the subject of so-called "scientific change ringing," a system by which, starting with rounds, a new order of the bells is produced at each pull of the ropes, until without any repetition of the same change the bells come back into rounds. It is easy to see that the number of possible changes on a set of bells, *i.e.*, on three bells—six; on four bells—twenty-four; on five bells—one hundred twenty, etc. On eight bells then, 40,320 different changes may be produced. Actually to ring this number would require about 25 hours of continuous ringing. Any number of changes over 5,000 is technically known as a "peal" and this, requiring a little over three hours, as the standard length of scientific ringing. Every week in England there are probably fifty or more "peals" rung by organized bands besides the thousands of short performances, known as "touches," which are rung for services on Sundays and special occasions. And occasionally an attempt is made for a record peal. I believe the longest thus far rung was of over 17,000 changes which meant uninterrupted ringing for more than eleven hours. You may be wondering how each man can possibly remember where his bell should strike in the varying changes; even if only a few changes (100) are attempted. Of course he could not memorize his individual places; but he can follow certain general rules in the changes of place, which will give him, as it were, a path among the other bells. For a bell never changes more than one place at any pull, that is, a bell striking third in any change will strike either second or fourth at the next. Thus each bell, therefore, is moving, as it were, either up or down among the others, and must follow the rules which govern its path in the particular method rung A "Method" means a system of rules which regulate the work of each bell so as to produce the definite number of changes desired. The invention and application of these methods offers a fascinating opportunity for almost unlimited mathematical ingenuity. Furthermore there is scope for a certain exercise of musical taste in composing peals. For though on seven bells all possible changes have to be employed to produce the 5000, on eight or more a large choice can be made, and the object is to select the changes which are generally considered as musically most pleasing. The whole subject is however hopelessly beyond the scope of my paper. There are signs of a growing interest in change ringing in

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this country. A beautiful set of bells has been imported and hung in Chicago University, and others were offered to the Federal Government for the new Custom House building in Boston. In this latter case, unfortunately, the gift was refused, owing to the narrow-minded opposition of the American bell manufacturers. I believe, however, that a practice which has for nearly 300 years kept up the ranks of its enthusiastic devotees among our brethren across the Atlantic, is likely sooner or later to win its way over here.

In connection with the demonstration of bell ringing, which came later, Mr. Sturgis made the following remarks:—"Now just one word of explanation concerning the illustration of bell ringing which will be given a little later. We shall first ring (as the program states) a 'touch' on the hand bells. These are small bells tuned to the same key as the tower bells, and are useful for practicing the changes in the various methods. Thus far, our band of ringers have only attempted changes on five bells, the sixth bell 'covering,' that is ringing last every time. After the hand bells, we shall try the eight tower bells which themselves are of unusually sweet tone, and I am trusting to them to make up for any imperfection of our ringing, for our bell crew does not pose as experts, being composed of members of the school."

As a preface to his Demonstration of Chladui's Figures, Mr. Parish said that the difficulty in teaching vibration of plates in secondary schools lies in the fact that many teachers do not realize how hard it is for pupils to understand how a medium can vibrate as a whole and in parts at the same time. Before going into this subject, therefore, some preliminary demonstration should be taken up to show plainly these complex vibrations.

Two such sets of experiments were performed; one with a long steel rod, and the other with a coil of spring wire.

The rod was clamped upright in a vise at its lower end, and first made to swing from side to side as a whole. Again, when set in vibration at a point one-third way up, it was found to have a node one-third way down from the top, thus vibrating in thirds. While this last vibration was going on, the whole rod was made to swing from side to side, thereby showing two sets of vibrations taking place at the same time. Further, when the rod was held firmly between the fingers at its middle point, and struck a sharp blow with the other hand at a point one-fourth way up, the removal of the fingers revealed the fact that the middle point and the top were nodes. Here again, as before, the whole rod was made to swing at the same time.

The coil of wire was used to illustrate the vibration of air columns. The coiled wire spring, preferably of bright copper, so as to be plainly seen all over the class room, was used, first, sup-

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ported at its lower end, and, secondly, suspended from its upper end. In the first position, an impulse given to the upper end was seen to pass down and back, the point of greatest vibration being at the top or free end. (In the vibrating column of air, the open end is the point of greatest vibration.)

In the second position (of suspension), the spring was first set in vibration as a whole, as in the first position, and then, with a point one-third way up held firmly, it was made to vibrate with a node at that point held. While so vibrating, it was swung from side to side as a whole.

A representation of the manner in which these vibrations take place was shown on a modified form of Crova disc, with its eccentric circles so arranged as to show the node.

After these experiments, the vibration of the tuning fork as a whole and in parts followed.

Next came the vibration of plates, circular first, followed by the square one. Many interesting experiments were performed, beginning with the simple case of the plate dividing into four parts, and by steps working up to sixteen parts. (Under good conditions Mr. Parish has been able to get the circular plate to divide into forty-four parts radially.)

For the higher number of divisions a pair of wooden pointed calipers were used for damping, thereby getting much more accurate results than could be secured with the hands. The distance between the points was obtained from a card on which was a curve, like the curve of the plate, marked off accurately.

For getting the radial nodes these caliper points were applied close to the edge. When, however, the damping was done at points some distance in from the edge, the segments were made to vibrate in parts, and several very complicated figures were thus brought out. Particularly was this true in the case of the square plate, when a single wooden point was applied at various places on the plate.

Mr. Crane's talk on "The Physics of the Pipe Organ" finished the morning session.

THE PHYSICS OF THE PIPE ORGAN.

It is to be hoped that all the guests of the day are not skillful organists. but even if you are it is quite reasonable to assume that the complex mechanism of the up-to-date, fully equipped pipe organ, the cause of many of the delightful effects obtained, the quickest way to get at the 1001 internal adjustments are not at all *fully* understood by every one present. A man may have perfect technique, most thorough knowledge of musical composition, a very keen ear for the most effective blending of tone, a clever management for harmonic effects. and still be utterly helpless when the

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organ becomes out of order;—and all organs do become so at times, being subject to atmospheric changes beyond our control. The skillful organist may charm his audience and at the same time not know anything of the construction of the instrument beyond the keys and stops which he manipulates.

The organ has been called "The King of Instruments" by many; as far as it represents different orchestral instruments, its control of great variety and volume of tone, this may truthfully be said; but with all its resources it is still imperfect, being unable to produce that individual personal "tone-color" possible only by as many skillful orchestra players as the organ represents. But even with its limitations it does bring under control of one performer greater musical resources than any other single instrument.

It is quite superfluous to compare the organ of fifty years ago with that of the present day. It is true that some of the best tone production, though limited in variety, is to be found in organs of earlier construction, but that is about all that can be said in their favor.

Electricity applied to organ construction has entirely revolutionized the instrument by both improving the former product and making possible well nigh countless changes, otherwise entirely impossible.

The means by which each key controls each speaking (or sounding) pipe with which it is connected, are either TRACKER ACTION, PNEUMATIC, ELECTRIC or ELECTRO-PNEUMATIC ACTION.

The TRACKER action is the earliest method and in action, is a simple lever, the arms of which are thin narrow strips of wood; although this method has the virtue of being prompt in action it is by no means noiseless and its use is very much limited. With this action only, many of the effects of the modern organ would be impossible. None of the large organs of latest type are tracker action, and the best builders nowadays have entirely abandoned that method of action.

The PNEUMATIC action was next introduced. The advantages of this over tracker action are evident; it is prompt, quiet, and permits many of the modern facilities impossible with the tracker action. It has uniform pressure at the keys regardless of how much power is supplied or how much volume is produced. If a large modern organ were equipped with tracker action it would require almost the power of one's fist to each key when playing full power. Pneumatic action is limited, however.

The next method of action was ELECTRIC, which involves all the good features of the preceding, having none of their defects. It is instantaneous, noiseless, and makes possible still greater effects

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and improvements in general. The best builders of the day employ the combination of pneumatic and electric action, which is almost without fault; it is very prompt under all conditions of power used and all varying pressures applied from the wind supply; the touch is uniformly light. Our chapel organ has electro-pneumatic action. It requires no more pressure to play on a key connected with the largest and loudest pipes than it does to play when only the very smallest pipe in the organ is used alone. This two-fold action makes it possible to produce an almost unlimited number of combinations of tonal effect, without removing the hands from the keyboards, as will be demonstrated later in the chapel. This action, too, permits almost unlimited rapidity of playing, being prompt and certain at the same time.

In a very large organ, such as the St. Louis Exposition Organ, actually the largest in the world, there are 1300 magnets, over 130 miles of wire and over 7000 open circuits. The organ in our chapel is one of moderate power, virtually consisting of four separate organs electrically connected so that any two, or three, or all four may be played simultaneously. The motive power is a 4-horse-power water motor.

The pipes used throughout the organ are either of wood or metal; as to construction are either "flue" or reed pipes; as to tonal effect they represent most instruments used in a large orchestra, as strings, "wood-wind" and brass, as well as several distinctive organ tones not found in any other instruments.

Wood pipes are of two classes, open and stopped (at upper end), the open being generally preferred, as will appear later; though a few stopped pipes add somewhat to the general effect when used in combination with others. The metal pipes are never "stopped" unless the height of organ chamber limits them, and even then it is more satisfactory to have them bent at an angle and left open, than half the length stopped. While the wood pipes are usually of the same material, pine, the metal pipes vary greatly, from pure zinc to various percentages of tin and zinc and other metals. Generally wood pipes are rectangular, being square-base prisms; one most notable exception, however, is in the set known as the Folete (spoken of later). Most of the metal pipes are right circular cylinders, though certain pipes representing brass and reed instruments are conical, in termination, or have detached caps, or barrel shaped.

The lengths of metal pipes vary from 16 ft. to .75 of an inch, that is in organs of moderate size, and from 3 ft. to less than an inch in circumference.

Wood pipes vary in length from 32 ft. to 1.5 inches, and in perimeter from 10 ft. to an inch; the longest pipe that will produce

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a definite pitch is about 64 feet, and of little value except when used with many others of a large organ. An 8′ open pipe produces C, 4 whole tones lower than the average bass of a singer's lowest note. A stopped pipe produces a note an octave higher than an opened one of the same length. The weight of the longest wood pipe is 1800 pounds, about 9-10 of a ton, and that of the shortest about an ounce. The weight of the longest metal pipe is about 900 pounds and the shortest 1-2 ounce. The organ in our chapel contains 1772 pipes, while that of the St. Louis Exposition had 10,059 pipes, which makes a total of 140 stops but to this number of speaking stops must be added 99 mechanical stops, so that the St. Louis Organ has 239 stops at the command of the player. The Ocean Grove organ, about which much has been written, is the second largest in the world, having but 171 stops, 24 of which are as yet dummy piped. This organ I might say is of the so-called "borrowed" type. This can be illustrated as follows:—one stop will be marked "Oboe," and on a different key board the stop for the same set of pipes will be marked "French Horn" and on another (or even the same) key board playing an octave higher it will be marked "Gambetta" and on another manual playing an octave lower marked "Orchestral 'Cello," and in the pedal organ called "Tuba Mirabalis," etc., being all the same *one* set of pipes; so that 18 sets of pipes will furnish *75* stops instead of *18;* great scheme for the builder but it fools many church *music* committees who, generally speaking, have no *musical* ability, judgment or wisdom, but simply control the ducats. It also deceives the organist generally because it happens that the builder of such an organ is exceedingly clever in his harmonic effects; case of *stock* diluted with H_2O; *aroma* of CS_2; precipitate of Au_2S_3.

The sounds which we are able to detect by the ear are caused by vibration. In the pipe organ there are two distinct classes of vibrating body: (1) air columns set in vibration at the mouth of the pipe by air under pressure; (2) reeds, of brass either enclosed in metal pipes or not, set in vibration by the same means as the air columns. Each organ pipe produces its fundamental or primary tone; if each pipe produced this only and nothing more, a very large part of the pleasing effect would be lost, but the air columns vibrate in parts as well as a whole. To illustrate this let us consider the vibrations from a stringed instrument, say a piano. A given wire in the piano vibrates as a whole, producing the fundamental tone or pitch; *but* at the same time vibrates in halves, and the halves in turn in halves, etc., the vibrations from the fractional parts being successively fainter; it is these *extra* or fractional-part vibrations that furnish a very large part of the *character* of the tone, and they are commonly called *overtones.* In instruments

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yielding few overtones the quality of the tone is less agreeable to the ear. The Jew's Harp gives forth its fundamental tone strongly and its overtones few and relatively faint, so that the tone is described as "thin," and this one dominating tone is evident even when other pitches are derived, since it is in reality a single vibrating reed. Whatever "music" may be attempted on it the fundamental tone is not only evident but also constant.

Overtones are present in speaking (or sounding) pipes, each over-tone being different in pitch and successively decreasing in intensity. In closed pipes only those overtones which correspond to the *odd* multiples of the fundamental-tone number of vibrations are present, while in an open pipe those overtones which correspond to both the odd and even multiples of the fundamental tone number of vibrations are present, and hence are more pleasing to the ear and relatively more brilliant. Of these overtones many blend most pleasingly, and this *blending* is known as *harmonics*. Different ratios of blending produce very different harmonic effect. The clarinet, for instance, produces overtones which correspond to only the *odd* multiples of the fundamental tone's vibrations, and at the same time is an open pipe; its characteristic quality of tone is largely due to this fact. Flutes, generally *open* pipes, have odd and even multiples of fundamental vibration frequency, replete in harmonics and are hence "rich" in tone. A brilliant and bell-like tone is derived from a set of pipes in our chapel organ in a peculiar manner. This stop is known as the "Floete"; it is double mouthed, oppositely placed, made of wood, rectangular prism but with base *not a square*, and is a stopped pipe. Under these peculiar constructive conditions it produces a most delightfully pure tone, and will be illustrated later in the chapel. Much of the distinctive quality derived from metal pipes is due to the percentages of metals used, some very effective string effects being produced by as high as 95 per cent. pure tin alloyed with zinc, and the regular relative proportions of construction being materially altered.

The reed pipe is of metal, varying in form, from right circular cylinder to inverted conical, and of varying percentages of alloyed metals. The brass reed is set longitudinally in the pipe at the base; similar laws for reeds as to length, relative width and thickness, are adhered to as in construction of pipes; the tone produced by the vibrating reed is augmented by the vibrating air column of its pipe. The free, or non-enclosed, vibrating reed may be very much less characteristic of distinctive tone-color, as is heard in the harmonica, "seraphine," melodian, "parlor organ," so called, though it really is best adapted to the deaf and dumb asylum. Some makers, however, of most ambitious type have produced fairly good tones from their reed organs by having each reed set

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in a resonating tube, carrying out the analogy of the production of human voice. Reed pipes generally cause more trouble than all the other pipes in the organ together; but some of the most progressive builders have overcome this difficulty to a surprising degree by making a reedless reed-pipe. This is done by certain metal alloys, and modifying the form of the pipe to one similar to a barrel, of slender proportions. These reedless reed-pipes generally remain in tune and are not so sensitive to atmospheric changes as the regular reed pipes.

The VIBRATION FREQUENCY in organ pipes varies from 16 to 8182 per second. The lower vibration frequency affords but little of real musical value as foundation tones, but are valuable as harmonic sources; the higher add brilliancy, for many *are* overtones of the low vibration frequency, but *their* overtones are too high and too weak to have much value.

The Diaphone is a comparatively new stop. It is of great value in its "carrying" power, strong but not disagreeable. It is a metal cylinder set in vibration within another closely fitting cylinder, and is used only in large organs.

The WIND PRESSURE in pipe organs varies in different departments of the organ, and often is different for certain distinctive stops. The pressure varies from 3.5 to 4, 6, 10, 15, 20, 25 and even 50 inches in the largest organs, and means that the wind supplied to the pipes would raise a column of water these heights respectively.

The quality of the tone of our chapel organ is regarded by competent judges as superior to many. While it is true that the tone is of excellent quality, some of the credit is due to the placing of the instrument. It is built in an ample stone chamber, the only open side being the front, or case, of the organ. The same organ placed on the floor level with all sides open would sound far less agreeable, and many of the most advanced organ builders will not build an organ of moderate size unless it is enclosed in specially constructed cement chamber, realizing how much it adds to the tonal effect. Our organ contains one set of pipes, installed after the organ was finished, known as the "Vox Humana," an exact copy of that stop in one of the noted cathedrals abroad. It is of peculiar quality and in certain combinations resembles closely the human voice, especially at a distance. Some of the characteristic effects you will be invited to hear, but as life is short at the most, I will not ask you to hear all of the possible combinations of tonal effects produced by the stops only, of which there are 32, since they are limited in number to 4,894,967,295.

Those present were then invited across the Campus where the demonstration of the hand bell and tower bell ringing was very

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efficiently performed, to the great enjoyment of all. Those who desired were allowed to climb into the belfry and see the crew at work, as well as see the bells in action.

After this the organ recital in the chapel furnished a very pleasant quarter of an hour.

The demonstration of the Physics of the Pipe Organ had to be omitted, owing to the lateness of the hour. This was a great source of regret to all.

A most elaborate luncheon awaited the gathering in the library, and a pleasant social half hour passed there.

The afternoon session opened with an address by Professor Sabine of Harvard, an abstract of which follows:

Mr. Sabine gave an account of current experiments in the general subject of architectural acoustics, relating particularly to the phenomena of interference and resonance. Apparatus was described whereby photographs were taken, recording the intensity of the sound continuously along a fine spiral from the walls to the centre of the room while a steady source of calculable intensity is sounded at a particular portion of the room. From these photographs contour lines had been plotted showing the distribution of intensity of sound in the room. Samples of the photographs recording the intensity of sound and a map of the contour lines of intensity were shown the members of the Association. This contour map showed regions of almost complete silence with regions of great intensity, arising from the destructive or reinforcing interference of the sound coming direct from the source and the sound which had suffered one or more reflections from the walls, ceiling or floor.

In these experiments the paradoxical result was shown that with a constant supply of energy to a source such as an electrically controlled tuning fork, the intensity of sound in a room, not merely at a point, but throughout the whole room, may actually be increased by the introduction of absorbing material. This phenomenon is due to such a shift in the interference system as to bring a node instead of an antinode, and that node opposite in phase, at the source of sound. There thus arises a new definition, or at least a new point of view, of resonance, in its application to the case of a source of sound entirely within a closed space.

Following Professor Sabine's address a motion was made and carried that Mr. Fred A. Cowan represent the Association at the N. E. A. in San Francisco this summer.

Mr. Packard then spoke informally on "The Mechanism of the Ear," showing first five slides he had taken from a copy of the

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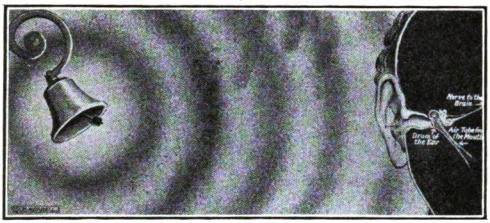
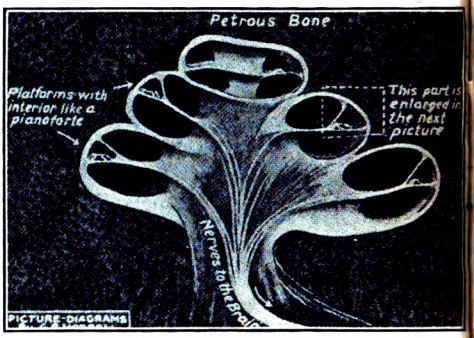
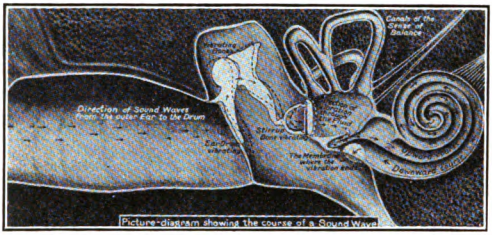
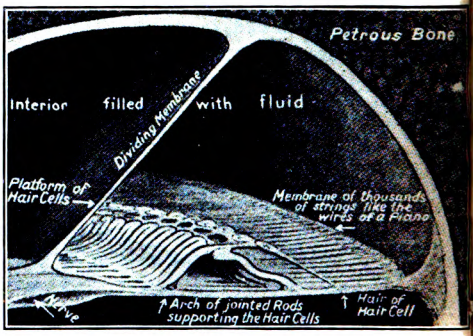
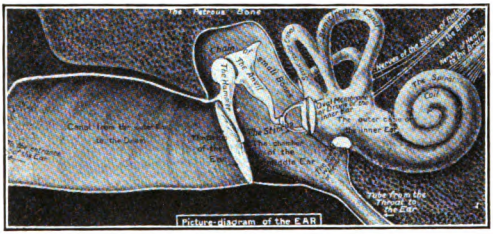
Children's Encyclopaedia, Part 37, published in London. He presented these because of the extreme ease with which they could be understood. Copies of these pictures follow, and explain themselves.



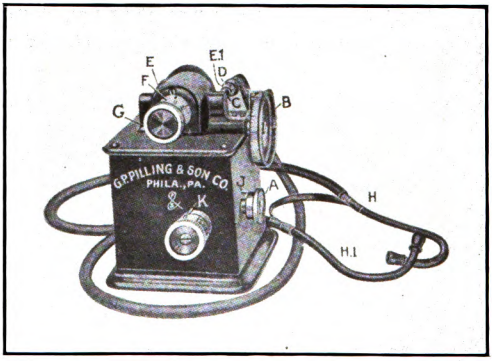

Petrous Bone
Platforms with interior like a pianoforte
This part is enlarged in the next picture
Nerves to the Brain
PICTURE-DIAGRAMS




Petrous Bone
Interior filled with fluid
Dividing Membrane
Platform of Hair Cells
Membrane of thousands of strings like the wires of a Piano
Nerve
Arch of jointed Rods supporting the Hair Cells
Hair of Hair Cell



He then showed an audiometer, a picture and description of which follow:



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DEMANDS FOR A GOOD AUDIOMETER.

Psychologists have long felt the need of an instrument that would measure with accuracy the acuteness of hearing.

Aurists and schoolmen have also felt the need of such an instrument, with the additional requirement that it be so simple that it can be operated with ease and rapidity in such environments as the office or the school room.

The Audiometer represented in the accompanying cut can be used in the most quiet room for making the most delicate tests, and it is so simple and easy of manipulation that aurists and schoolmen can make tests with accuracy, ease and rapidity, even with the noise of the ordinary office or schoolroom.

FUNDAMENTAL FACTS.

The operation of this machine is based upon the fundamental facts that constant sounds of a low intensity can be confined in a box, and that when an opening is made in this box the loudness of the sound passing through this opening will increase when the opening increases, and diminish when the opening diminishes.

ESSENTIAL FEATURES.

The structure of the instrument consists essentially of a device for making a constant sound within a practically sound-proof box, having an opening that may be varied, and tubes to carry the sound from the opening to the ears.

DETAILED DESCRIPTION.

To go more into details, the instrument consists of a cast iron box about 4 in. x 4 in. x 4 in.

The Hammer Wheel.—In this box is an apparatus for making a constant sound, which consists of a metal hammer suspended on a pivot passing through the handle. By turning wheel "A," the Hammer Wheel, a wheel with six teeth inside the box is turned. Each one of these teeth in turning engages the hammer handle and always lifts the hammer the same height, when the tooth disengages the handle and allows the hammer to fall by gravity upon a small bell, thus always producing the same sound. There are six marks on the inner rim of wheel "A," corresponding to the six teeth on the wheel inside the box.

When one of these marks passes the pointer "J," the operator knows that the bell has sounded.

The V-Shaped Opening.—The only way for this constant sound to escape is through a V-shaped opening in the cover of the box beneath valve "F." This V-shaped opening is opened and closed by a slide, which is moved at will by turning wheel "B." This wheel is graduated into 100 equal parts, so one can tell at any time, by simply reading the number opposite the pointer, the size of the V-shaped opening through which the sound is passing, and, since

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the size of the opening determines the loudness of the sound, the figures on the graduated wheel will also indicate the loudness of the sound passing through the V-shaped opening.

Wheel "B" is graduated from zero to 100. When the index points to zero, the V-shaped opening is entirely open; when it points to 100 it is very nearly closed; therefore, if one cannot hear at zero he is deaf to the sound produced by this machine. If he can hear up to 100 his hearing is acute.

The sound, after passing through the V-shaped opening must pass through the three-way valve "F," and then through the brass tubes "E" and "E 1," which are connected by means of rubber tubes with the stethoscope tubes "H 1" and "H." The stethoscope tubes with the *curves up* are placed in the ears of the subject to be tested.

The Three-Way Valve.—There are four letters, "R," "B," "L" and "C." on the face of valve "F." When "B" is straight up the sound is turned into both ears; when "R" is up the sound is turned into the right ear and off of the left ear; when "L" is up the sound is turned off the right ear and into the left ear; when "C" is up no sound passes into either ear.

Set Wheel.—Wheel "K"—set wheel, regulates the distance the hammer falls on the bell. This distance increases as the wheel is turned from 0 to 10, and, consequently, the loudness of the sound of the bell increases.

President Griswold closed the afternoon session with a few remarks about the school, saying that, while the impression was abroad that the school was a wealthy one, as a matter of fact, there was no endowment. The school is twenty-seven years old, and at present has an enrollment of one hundred and sixty boys. Of late it has been a desire to make the character of the school more cosmopolitan, and with this end in view every year several boys are taken in on the basis of scholarship, part of the tuition fee being remitted. This fact he desired the Physics teachers to bear in mind. He extended an invitation to all who desired to stay until the late train to go about the buildings and grounds.

At the close of the afternoon session it was voted that a written vote of thanks be extended by the secretary to all those at Groton who had acted as our hosts, for the magnificent and most entertaining reception they had accorded us.

Of the fifty odd members present, about one-half availed themselves of the opportunity to visit the places of interest about the school, and an interesting hour was spent in the museum, printing room, school laboratories and recitation rooms of the main school building, in which, among other things, were the complete set of the famous Audobon pictures, and autograph letters of many of the Presidents of the country.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SIXTIETH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, December 2d, 1911

at Harvard University, Cambridge, Mass.

AFTERNOON MEETING.

2:00 *P. M.*

Meet at Harvard College observatory, Concord Ave., Cambridge, Mass.

Short talk on the observatory and work carried on there, by EDWARD CHARLES PICKERING, L.L.D., Director of the observatory.

Tour of inspection of the observatory buildings and grounds.

3:15 *P. M.* Astronomical Laboratory, Jarvis Street.

Business Meeting.

Reports of Standing Committees.

Committee on New Apparatus,
HOMER W. LE SOURD, *Chairman.*

Committee on Magazine Literature,
FRANCIS R. HATHAWAY, *Chairman.*

Committee on Current Events in Physics,
FRANCIS E. MASON, *Chairman.*

Election of New Members.

3:30 *P. M.* Annual address of Vice President.

Some Remarks Concerning the Eastern Association of Physics Teachers. FRED H. COWAN, Girls' Latin School, Boston, Mass.

3:45 *P. M.* *The Eye.*

DR. ARTHUR AMADON, Boston Mass.

4:00 *P. M.* *The Compound Microscope.*

DR. HARRY W. MORSE, *Harvard University.*

Following this meeting, there will be a trip to the Alvan Clark Lens Works on Henry street, Cambridge, Mass., where the manufacture of lenses will be demonstrated.

EVENING MEETING.

Saturday, Dec. 2d, 1911, at Boston City Club, 9 Beacon street, Boston, Mass., Annual Smoker.

7:00 *P. M.* Dinner.

After-Dinner Discussion: *The Scope and Content of a Physics Course in Secondary Schools.*

General Topic.

Sub-Topics: *Heat*; *Light*; *Sound*; *Mechanics*; *Electricity.*

(Speakers to be announced.)

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AFTERNOON SESSION.

HARVARD COLLEGE OBSERVATORY.

After being introduced by President Griswold, with about fifty members present, Professor Pickering spoke briefly of his early training as a physicist When, in 1876, he was appointed as director of the Astronomical Laboratory at Harvard, astronomy was a pretty barren subject there, as there was little in the way of apparatus. Since then the observatory has gradually developed along special lines with the subject of photometry uppermost. In this the relative brightness of stars has been carefully studied and records kept. Over 2,000,000 observations of starlights have been made. For the purpose of studying the southern skies not visible in the northern hemisphere a southern station was established at Arequipa, Peru.

Since 1890 sets of photographs of the entire sky have been made year after year, so that a complete history of the changes that have been taking place is recorded and accessible to any one desiring information about star location and changes in any particular part of the sky. This set of photographs is the only one of the sort in the world and furnishes a reference for the world. A staff of assistants is constantly at work attending to this collection, and copying records for use elsewhere.

The tour of the buildings and grounds included an inspection of the building in which the records are kept, with the methods of carrying on the work; a visit to the first telescope acquired, which stands some thirty feet above the ground on a rock base extending twenty-six feet into the ground; the telescopes, with which the photographs are taken; and finally the room in which transparencies of the photographs of most interest are shown. In this last room were shown the places where are located instruments other than those at Cambridge, star clusters of various kinds, double stars, methods of determining variables, spectra, the different planets, and many other things of interest.

Much of interest about the grounds had to be omitted owing to the lateness of the hour.

ASTRONOMICAL LABORATORY.

Report of Standing Committees.

The report of the Committee on New Apparatus follows:—

The Holengren Worsteds for testing color sense were shown by Mr. LeSourd. This is the standard set used for the examination of pilots, railway employees and recruits for the army and navy. A skein of the test color is placed on a white surface before

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the person under examination, and he is asked to select from one hundred and thirty small skeins the ones most resembling this test skein in color. By testing members of a class privately it is easy to determine which are color blind. The Young-Helmholtz Color Theory becomes a most interesting topic when one pupil, who has been found to have defective color vision, gives a demonstration before the class by attempting to match colors. This set can be purchased from Muller & Weltch, Boston, the price being $5.00. The Century Magazine for April, 1907, presented an illustrated discussion of "Color Blindness" which is comprehensive and reliable.

Mr. George A. Cowen showed a lamp-chimney simple and compound microscope, made by using a student lamp chimney, a 5cm focus lens, and a 15cm focus lens. In the model, the short focus lens is held in place by a carrier made of ivory soap. A five-cent cake will make a dozen carriers. The other lens is kept in place by the constriction in the chimney.

The advantages of the microscope are, that every part of the barrel is visible, so that there can be no secrets of construction, that the distance between the two lenses can be measured, and the magnifying power be determined. It is interesting to find that the actual corresponds so nearly with the calculated.

The effect of compounding can be so easily seen that it is a pleasure for the pupil to work out the problem.

A full sized drawing of the microscope can be made in the note book, showing the exact sizes of object and images at their proper distances.

Mr. Andrews showed a simple photometer made from two pieces of opaque glass separated by a thin piece of paper and the whole cemented into one piece. The two pieces of glass show different tints when light from two sources fall on them if there is any difference in intensity.

The Ives Chromatic Discs for illustrating the mixture of colored lights were shown. These lantern slides are made up of three thin glass plates with a color disc on each so arranged that the discs overlap, producing white light by means of the slide containing plus colors and giving a black centre where the negative colors overlap. These are sold by the Scientific Shop of Chicago.

Report of Committee on Magazine Literature.

Century Magazine.

July—Edison on Invention and Inventors, Waldo P. Warren.

Electrical World.

October 14, 1911—Wireless Telegraph Antennae, with diagrams, David Darrin.

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Harper's Monthly.

August, 1911—The Prizes of Chemistry, Prof. Robert K. Duncan.

Popular Mechanics.

A series of articles on The Kingdom of Dust, by J. Gordon Ogden, Ph. D. (continued from May), under the following sub-titles: IV., The Earth's Winding Sheet (June); V., The Foe of the Workman (July); VI., (August); VII., The Friend of the Housewife (September); VIII., The Right Hand of Death (October); IX., Perfumes and Odors in Dust (November).

September, 1911—Searching for the Electric Atom, David A. Keys. Recording Sound by Photography, Dr. A. Gradenwitz. Lightning Explained by a New Theory.

October, 1911—A Real Revolution in Automobile Engine Design, Anton Camille.

November, 1911—The Puzzle of the Electric Light Bill, Henry Tarkington.

Scientific American.

Several Biographical Sketches: (1) Col. George W. Goethals, Canal Builder (June 10, 1911); George Elery Hale, America's Foremost Solar Physicist (July 8); Henry Walter Nernst, a Great Physical Chemist (Sept. 23); Marie Sklodowski Curie (Nov. 25). A series of articles entitled A Landsman's Log Aboard the Battleship North Dakota, containing information regarding operation of guns, target practice, etc, by J. Bernard Walker (Oct. 4, 28, Nov. 4, 25, 1911). A series of articles on How I Invented the Air Brake, by George Westinghouse (June 17 to July 8).

June 10, 1911—Eliminating the Scratching Sound in Gramophone Reproduction.

July 15, 1911—Designing and Constructing an Ocean-Going Steamer, W. A. Dobson, of Cramp & Sons' Shipyard.

July 22, 1911—Maintaining the Stability of Aeroplanes by Means of Gyroscopes.

August 5, 1911—The Aviation Motor; Recent Developments in France (Gnome Motor).

August 12, 1911—The Engineering Work of the Reclamation Service, A. P. Davis, C. E.

August 19, 1911—Water in Motion; Some Examples of the Tremendous Energy of Waves and Floods.

August 26, 1911—A Study of the Giant Airship of the Future, Carl Dienstbach.

September 16, 1911—How Electricity is Aiding the Chemist,

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Prof. W. H. Walker, Mass. Institute of Technology. Testing before Buying; article on large testing machines, Dr. Charles F. McKenna.

September 30, 1911—Power from Sunshine, Frank Schuman.

October 7, 1911—The (Gas) Meter.

October 14, 1911—How to Make a Model Aeroplane Driven by Elastic Bands, Cecil Paoli.

November 18, 1911—Perpetual Motion; some excellent examples of misguided ingenuity.

November 25, 1911—Zeppelin's Schwaben: a high speed aerial craft for passenger service, Carl Dienstbach. The Demand for Young Men in Electrical Engineering, Prof. Dugald C. Jackson, Mass. Institute of Technology.

Scientific American Supplement.

Lectures on Radiant Energy and Matter, delivered by Sir J. J. Thompson at Royal Institute (June 10 to July 15, 1911).

September 2, 1911—The Electron Theory Simply Explained, Lindley Pyle, A. M.

September 16, 1911—Simple Experimental Evidence for the Presence of Ions, Charles W. D. Parsons.

September 30, 1911—Lifting Magnets in Foundries—A Simple Electroplating Apparatus for Amateurs.

October 21, 1911—The National Bureau of Standards and Its Work, S. W. Stratton.

November 4, 1911—Recent Advances in High Temperature Measurements, J. A. Harker, F. R. S.

November 11, 1911—The Manufacture of Permanent Magnets, F. B. Hays. Radio Telegraphy I.—part of a discourse given at Royal Institute by Commendatore G. Marconi.

School Science and Mathematics.

October, 1911—Address, with experiments, upon Sound Waves: Their Meaning, Registration and Analysis, Charles C. Miller. Should the Content of High School Physics be Changed?, Burton E. Smith. Two illustrated articles on An Apparatus for the Study of Gas Laws.

November, 1911—The History of the Introduction of the Idea of Centrifugal Force, Murray C. Hobart. The Force Exerted by Freezing Water, Benjamin H. Brown.

Technical World.

July, 1911—The Strongest Pipe in the World (it conveys water from reservoirs on Pike's Peak to Colorado Springs), Glenn Marston. Idaho's Huge Magic Dam; plan for irrigation of volcanic ash area, Day Allen Willey.

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October, 1911—The Pivot of Trade; describing methods of handling coal and ore on a tremendous scale, on the Great Lakes, George H. Cushing. Raising the Maine: description of caissons, etc., Chester Carter.

November, 1911—Gravity Conquered at Last; description of an Invention of a New York engineer, Robert H. Moulton. Learning to Use Light; article on scientific distribution of light in halls, show windows, etc, Charles F. Carter.

December, 1911—Visions of 1950; a prophecy of future possibilities in science, E. I. La Baueme. How Air Craft are Controlled, Edward I. Pratt.

FRANCIS R. HATHAWAY, Chairman.

Report of Committee on Current Events in Physics.

The melting of metals in a vacuum gives a superior product because oxidation is prevented and gases present in the metal are expelled. Metals ordinarily brittle can be made malleable and ductile by this method. Tungsten and Tantalum, which can be made into wire by this process, are used as filaments for incandescent electric lights.

It has been found that the waterproof quality of concrete depends on the quantity of water used in mixing. A certain definite quantity produces the maximum of impermeability. More or less water makes the concrete porous.

In the Transvaal it has been noticed that bore-holes driven to a depth of 500 to 1000 feet show a strong deviation to the north. This is explained as being caused by the magnetization of the boring tool by earth induction. The deviation becomes pronounced as the depth increases.

At a recent electrical exhibition near London, the chief advances shown were in electrical cooking devices. Great economy of method was shown; also it was asserted that from an epicurean point of view the results of electric cooking are unexcelled.

Prof. A. F. Rogers of Stanford University has devised a specific gravity balance for solids which does away with calculation. The specific gravity is read directly from the beam as in the Westphal balance. With specimens of minerals weighing only two or three grams, the indications are accurate to the second decimal place.

Cooper Hewit has sought to remedy the mercury light by means of a reflector provided with a fluorescent film. It depends on the property of certain fluorescent substances to absorb the light which they return with its wave length greater, i. e. closer to the red end of the spectrum. This supplies the red rays lacking from the light of the ordinary mercury lamp.

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The new steamer "General," built at Hamburg, has a steadying apparatus designed by Mr. H. Frahm. It consists of a V-shaped tank placed crosswise the hull with one arm rising on each side of the vessel. This tank, partly filled with water, is proportioned so that the period of oscillation of the water, which rushes to one side as the vessel rolls, is exactly half the period of oscillation imparted to the vessel by the waves. The result is that as the ship tips one way the water rises on the opposite side and counteracts the effect of the waves. The tank is comparatively small, the arms being only about sixteen feet broad.

A recent method of producing Tungsten consists first of converting the metal into a phosphide, by heating with phosphorus. The ingot is then used as the cathode of an electrolytic bath, which reduces it to metallic tungsten in a more or less porous condition. The metal is rolled and hammered at white heat. The process is repeated to make the metal more ductile. When finally drawn into wire the metal is so flexible that it can be formed into filaments of any desired shape. F. E. MASON, Chairman.

The following new members were then elected to the Association:

Active—

Charles B. Harrington, Newton Technical High School, Newtonville, Mass.

William H. Timbie, Wentworth Institute, Boston, Mass.

William W Obear, Somerville High School, Somerville, Mass.

Associate to Active—

Harold C. Martin, South High, Worcester, Mass.

Associate—

Harvey N. Davis, Harvard College, Jefferson Physical Laboratory, Cambridge.

J. Hawley Aiken, Technical High School, Springfield, Mass.

Leonard O. Tillson, High School, Middleboro, Mass.

George W. Emerson, High School, Kingston, Mass.

George A. Cushman, English High School, Boston, Mass.

John C. Gray, Thornton Academy, Saco, Me.

Walter A. Mitchell, Soochow University, Soochow, China.

The annual address of the Vice-President was put over to the evening session and an instructive talk by Dr. Amadon then heard.

The Use of Spectacle Lenses for the Correction of Refractive and Other Errors of the Eyes and the Instruments Used for Determining Such Errors.

The use of lenses for the correction of ocular errors and for

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the improvement of vision goes back to prehistoric time. During the excavations of the ruins of ancient Nineveh a rock crystal lens was found, and in those early days the principles of reflection and refraction of light must have been well known. In our own England it is a matter of record that Roger Bacon, when he occupied the chair of Philosophy at Oxford, obtained some fine glass from Belgium and from this, with his own hands, made some spectacles by grinding and polishing the lenses, which were afterwards given to an elderly friend and worn by him previously to 1286. Charles V., after his death in 1558, left among his valuables twenty-seven pairs of spectacles. But it is only within the memory of the present generation that the refinements of ocular corrections have been possible, owing to more perfect knowledge of the conditions within the eye, more refined methods of examination and greater skill in lens making.

All combinations of convex, concave, cylindrical and prismatic lenses are used for the correction of ocular errors, and some ingenious devices have been used for properly adjusting and holding properly before the eyes the various combinations of lenses, from the clumsy split bifocal of Benjamin Franklin to the elegant invisible bifocal of today. The unit of strength of spectacle lenses is the lens which will focus parallel rays of light at one meter, or forty inches. This unit is called the Dioptric. A lens which focuses light at two meters, or eighty inches, has half the strength and is of the strength of half a Dioptric; one that focuses at half a meter is a two Dioptric lens, etc. Prisms are numbered according to their ability to deflect light, 1°, 2°, etc.

In speaking of the eye as an optical instrument I wish to emphasize one feature, viz., that, except for the tunics or limiting membranes, the eye is an elastic and fluid body, each surface of transparent tissue being a refracting surface. In front of the eye we have the cornea, a tough, resisting, almost perfectly transparent tissue, the front and back surfaces parallel and offering a strong convex refracting surface to entering rays. Posteriorly it is contact with the aqueous humor—a fluid of the appearance and consistency of water, hence its name, the aqueous. Limited by the cornea in front and the crystalline lens behind, it is in effect a strong concavo-convex lens and a powerful refracting medium. Behind this is the lens of the eye, enclosed in its elastic capsule, a semi-fluid, transparent, sticky substance, having the outlines of a double convex lens. It is supported at its edges by a ring of muscular tissue, called the ciliary ring or the muscle of accommodation. This ring, by its contraction, diminishes the circumference of the lens and allows it, by its own elasticity, to become more convex and therefore more highly refractive. Inasmuch as this

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increase of convexity and increased focusing power necessitate muscular contraction of the ciliary ring, which must be constantly exercised and under constant variation during accommodation, it is not difficult to understand why the accommodation becomes weary and exhausted after long continued use of the eyes, and particularly so in far-sighted eyes, which require constant focusing in order to bring the image on the retina at all. The lens is the only part of the eye that can be made to change its curvature at will and the only accommodative part of the eye. Behind this is the vitreous, a gelatinous, somewhat organized mass which fills the ball back of the lens. Thus we have a series of lenticular bodies, in contact with each other, each of different refracting power, not unlike the series of lenses found in high-class telescopes or microscopes. They are held firmly in contact with each other and under considerable internal tension.

A perfectly refracting eye is one in which parallel rays of light, on passing through the eye, are brought to a focus upon the retina without material accommodative effort, with the lens in its flattest condition, and with the muscle of accommodation relaxed. A far-sighted eye is one in which the refracting media do not bring the rays of light to a focus far enough forward to form a perfect image upon the retina, and the accommodation must be exerted in order to give clear vision. This accommodative effort in such an eye is constant and eventually brings on the usual signs of exhaustion, spasm of the accommodation, headache, blur, inability to use the eyes, etc. This is corrected by a convex lens. There is one other interesting point to make here. There is a certain relation between the effort of accommodation and convergence of the eyes. The greater the effort to focus the eyes the greater is the effort at convergence. This action is automatic and proceeds from and is controlled by nerve centres in the brain. If these relations are harmonious and well balanced, vision and accommodation proceed without undue strain, but if either is out of harmony with the other most disastrous nervous disturbances result. This is a fertile and interesting field of study and practice for the neurologist and ophthalmologist.

As one grows older the tissues become firmer and less elastic. This is true of the eye and results in hardening of the fluid lens, making it less elastic and more resistant to changes of curvature and at the same time the ciliary muscle is less able to influence the curvature of the lens. As the result of these two changes the accommodation for near vision becomes impaired and only by holding the object at a more remote distance can small objects be seen clearly and soon even that power is lost. A convex glass converges the rays of light and brings the focus to the retina—

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the thing which the unaided eye can no longer do. This failure generally begins at about forty-two years of age and becomes well marked at forty-five.

Near-sightedness is the condition in which the focus is in front of the retina. There is no relief by an accommodative effort because such effort would bring the image still further forward and aggravate the condition. As the result of non-use of the ciliary muscle it becomes weak and atrophied and the retina enfeebled. Such conditions tend to become more aggravated with time and neglect, and often almost total destruction of vision ensues. A concave glass corrects this condition.

The first recorded case of astigmatism dates from the year 1801. This term simply means that the curvature of the eye in one meridian is not the same as in other meridians, and while lines in one direction are well focused those in another direction are not so clearly focused, or, to state it in another way, the curve of the cornea is not a perfect spherical segment but somewhat flattened from opposite sides, or to speak more mathematically and exactly, its surface will not present that of a perfect surface of revolution, but that of a triaxial ellipsoid. This condition is most prolific of reflex disorders of all kinds and of severe character. Headaches, neuralgias, congestions, indigestion, confusion of mind, and a long train of symptoms are associated with this error. It is easy to see how difficult and well-nigh impossible it must be for the ciliary muscle to in any way correct this irregular and ill-balanced distortion of the cornea, and how exhausting such attempt must be. This error is largely located in the cornea—though not always nor entirely so. It may be caused by faulty development of the cornea or lens, by the unequal pressure of the lids upon the cornea, by the undue tension of the muscles which move the eye in its socket, or by irregularities in the bony walls of the orbit. It may be corrected by cylindrical lenses.

The muscles which move the eye-ball are mostly arranged in antagonistic pairs and on opposite sides of the ball, the contraction of one muscle and the relaxation of its opposite moving the eye in the corresponding direction. If these are not well balanced or improperly attached to the eye-ball this fault gives rise to a characteristic train of symptoms, like dizziness, nausea, pain in the back of the head, congestion at the base of the brain, etc. This error is corrected by prismatic lenses.

While each of these conditions, taken separately, seems to be amenable to correction, yet such is not always the case. They seldom come singly but usually several of them are combined in the same eye and often different complications in the separate eyes, so that the proper correction and balance of forces is far

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from easy and calls for considerable judgment and experience. The disturbance of nerve functions and perversion of sensibility associated with these errors often demand considerable insight into both the physiology and psychology of our patient.

Fortunately we have many instruments of precision to aid us in diagnosis. The use of the test lens and test card are familiar to all. Of the test lens I have already spoken. The test card deserves some mention. It is the result of much study and experiment. The basis of the system is as follows: The average retina can distinguish distinctly a space which subtends an angle, at the retina, of one minute. If we take five such spaces in each direction and outline our standard test-letter within that square and with each line of the letter one space wide we shall have a figure which will form an image upon the retina which will subtend an angle of one minute, which is as small as the majority of eyes can see. The distance for which such a standard letter is constructed is twenty feet, that being the distance at which lines of light are practically parallel, so far as the eye is concerned. For a greater distance a larger letter must be made and for a shorter distance a smaller letter. Hence the series upon test cards. If the twenty foot letter is seen at twenty feet the vision is said to be 20/20, the numerator being the distance at which the letter is seen and the denominator indicating the sized letter that is distinguished. If the forty-foot letter is the smallest that can be seen at twenty feet the vision is said to be 20/40, and so on. The opinion of the patient as to how well he can see and which lens gives the best vision is of value in proportion to the patient's perceptive powers, his habits of observation and comparison, his general intelligence and efforts at co-operation. But the results vary so much and are liable to so many errors, both of observation and judgment, that the examiner always distrusts his results obtained in this way and welcomes any device that eliminates the personal element from his work. Perhaps the simplest and most reliable of these is the retinoscope and the method of determining the refraction with this instrument is called retinoscopy or studying the reflection of light as thrown back from the retina of the patient. If a pencil of light is thrown into a perfectly refracting eye the light will be focused upon the retina and reflected back through the pupil, after passing through the various refracting media twice, in the same direction and in the same parallel condition as it entered the eye. If the eye of the observer be placed in the course of such reflected light he will be able to see the reflected image and study any slight movement he may impart to the entering rays as the light is reflected. The principle involved is that if the refracting media of the eye are so perfect as to converge the parallel entering rays and bring them

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to a focus upon the retina, the same rays reflected from the retina and passing through the same media in reverse order, will emerge from the eye parallel, as they entered. But if the refracting media of the eye do not focus the light perfectly, then the emerging rays will not be parallel and will not respond to the experimental movements of the rays and the variations will be interpreted by the examiner to indicate certain errors. When a lens has been placed in position in front of the eye, of such strength as to correct the observed errors, the reflected light will become parallel and so inform the observer. It is evident that this added lens will be the correction for the refractive errors of the eye. By this method the examiner can rely upon the infallible laws of light for his diagnosis instead of the fallible and uncertain observation and opinion of himself and his patient. Another valuable aid is the ophthalmoscope, which enables the physician to see the retina, directly and clearly, and at the same time note the strength of lens needed in order to get the most perfect focus upon the retina. This lens is the measure of the error of the eyes of both the observer and the observed. By subtracting the known error of the examiner the remainder is approximately the correction sought. Not only does this instrument help in determining the refraction, but enables the physician to actually see and examine in detail every part of the internal eye, the retina, the choroid, the vitreous, the lens, the iris, the aqueous, the cornea, and the optic nerve. The principle is simply to reflect light into the eye and, through a hole in the reflecting mirror, to look into the illuminated eye.

The ophthalmometer is an instrument used to measure the curvature of the cornea, and as most of the astigmatism lies in that tissue this instrument becomes of value in that condition. The instrument is complicated but the essential principle is simple. Two illuminated objects are placed before the eye and the light from each falls upon the surface of the cornea and is reflected forward to the observer, and the distance between the images is carefully measured. In point of fact, the objects are brought near enough to each other for the images to be in contact. Then the objects are revolved into a position at right angles to their former position and their distance apart is noted. If the cornea presents a perfect curve the distance between the images will remain as before. The difference in their distance in the different positions gives the data for computation of the curve of the cornea in its different meridians, and by repeating the observations it is not difficult to determine the meridian of greatest curvature and the meridian of least curvature. This will give the axis of the astigmatism and its amount. If the astigmatism were all in the cornea

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this would be absolute, but unfortunately for the usefulness of the instrument, the other media, especially the lens, may be the seat of astigmatism also, so that the ophthalmometer is of limited use only.

In describing these instruments I have eliminated many elements and modifications and have made statements which may not be absolutely accurate in order to simplify the descriptions and to emphasize the salient elements and principles of each. They all help in diagnosis but, after all, the use of common sense and experienced observation counts for much in adapting theoretical findings to the alleviation of suffering. We must always recognize that we have not only a delicate optical instrument with which to deal, but also a most sensitive living tissue.

Professor Harry W. Morse of Harvard University then spoke on the subject of "The Compound Microscope."

THE NEWER ADAPTATIONS OF THE COMPOUND MICROSCOPE.

The "Ultraviolet" and "Ultra" Microscopes.

Within the past ten years the compound microscope has been "specialized" to a remarkable degree. Objectives and eye-pieces had already become optically so perfect that we were at the theoretical limit of resolving power. This limit is given by two lines or two points in the object half a wave-length of light apart. The average wave-length for visual work is about 0.00055 millimeter (5500 tenth-meter units), and two lines closer together than 0.00025 mm. cannot be seen as separate lines. No structure having details finer than this is within reach of investigation by the ordinary microscope.

But we can shorten the wave-length of the illuminating light—and this is done in the "ultraviolet" microscope. A spark between terminals of cadmium gives a spectrum with a few strong lines in the region 2500-3000 tenth-meters. Light of this wave-length is wholly absorbed by glass, and all the optical parts of this microscope are made of fused quartz. Light from the cadmium spark is spread out into a spectrum by a train of quartz prisms, and the single line at about 2750 is used to illuminate the object. Condenser, objectives and eye-pieces are of quartz, and objects are mounted on quartz slides with quartz cover-glasses and in a medium (glycerine, for example) which does not absorb in this part of the spectrum.

This **doubles** our resolving power—enables us to resolve structure twice as fine as can be resolved with the ordinary microscope. And this is a great step in advance. But the ultraviolet

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microscope does more than this:—It carries us down into a region of new selective absorptions.

In visual work in the visible spectrum we can distinguish with ease things which differ in color. In preparations where the various parts are all colorless, we resort to staining to bring out the differences. The ultraviolet region gives us a new list of "colored" things. Fine particles of quartz and others of glass might be hard to distinguish with the usual form of microscope. In the ultraviolet instrument the glass is absolutely opaque—black—and the quartz is perfectly transparent. Every histological preparation examined in this ultraviolet light shows differentiations, even with low power lenses, which would be quite invisible in the ordinary microscope, and could only be brought out by careful staining.

The other present-day modification of the microscope is just as great an improvement. This is the "ultra" microscope. Its resolving power is low. It cannot compare with good objectives in the ordinary form of microscope in exhibiting details of structure. But it enables us to have **cognizance of** (not exactly "see") particles only one-fiftieth as large as the smallest thing that can be seen with the usual form of microscope. And it does this by changing the character of the illumination which is given to the object.

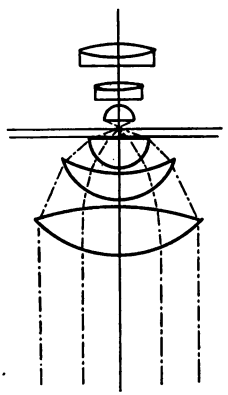

Fig. 1.

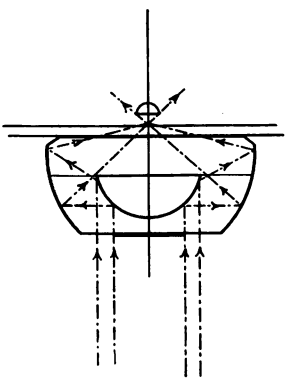

Fig. 2.

Figure 1 shows ordinary illumination by the sub-stage condenser. A large cone of light passes through the object and **into the objective.**

Figure 2 shows one form of illuminator for "ultra" work. The central stop at the bottom cuts off all light except what reaches the object at a very large angle. None of the light from

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the illuminator enters the lens, and the aperture of the objective is made small enough to insure this.

If there are no fine particles in the field no light enters the objective. If there is a particle in the field it looks like a bright spot of light. Light is diffracted when it passes by a small body and it is the diffraction pattern which we see, against the black background.

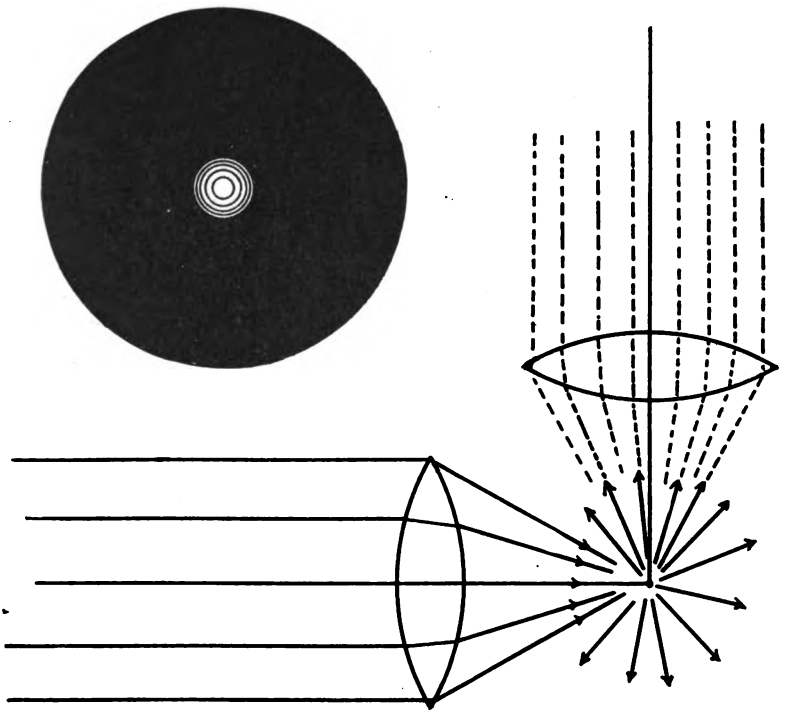

Fig. 3.

Figure 3 shows another way of producing the same effect, in this case by illumination from the side.

Illuminated in this way, a particle can show a diffraction pattern very much larger than itself—nearly fifty times as large, in fact, and we can therefore have cognizance of (not **see!**) particles only the hundredth of a wave-length in diameter.

Slides shown:—

1. Compound microscope. Optical parts.

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2. Modern high power objective.
3. Immersion systems and angular apertures.
4. Table. Numerical and angular apertures and resolving power.
5. Blood corpuscles (U. V. microscope).
6. Trypanozomes (U. V. microscope).
7. Theoretical limit of resolving power.
8. Substage condenser.
9. Dark ground Illuminator.
10. Ultra-microscope (diagram) and diffraction pattern.
11. Diffraction about a single small aperture.
12. Diffraction about a single small aperture.
13. Diffraction about a single small aperture.

At the Clark Lens works on Henry Street, Cambridge, which were then visited, those present had opportunity to see how lenses and flat surfaces were tested for irregularities, and listened to very interesting explanations of how lenses were ground, the different stages being shown by samples on hand. An interesting thing was the record of large lenses made, shown by black discs five in number, each representing what was at the time of its manufacture the largest lens in the world. Among them were the Lick and Yerkes, the best known of the five. The visit gave one a very good idea of the great skill that must be acquired before a perfect lens can be complete. It may be of interest to know that it takes from four to six months to grind a large 24-inch lens, and that on the larger lenses no work is done except by the elder Mr. Lundin or his son, who now have the running of the works, Mr. Clark being dead for many years.

It was through the courtesy of Mr. Lundin and his son that the members of the Association were given this splendid opportunity to visit this world-famed factory.

EVENING SESSION.

BOSTON CITY CLUB.

Immediately after dinner the annual address of the Vice-President was listened to.

SOME REMARKS CONCERNING THE EASTERN ASSOCIATION OF PHYSICS TEACHERS.

Fred H. Cowan, Vice-President.

It is not my purpose to give what could be called an address,

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but rather to offer a few words of appreciation of the Eastern Association of Physics Teachers.

You are most of you familiar with its history. You can recall that it had its origin in the deep-felt need of a few New England physics teachers who came together and organized the Association in 1895. During the sixteen years since its organization it has been a steadily growing power in the educational world, until we have reason to be proud of the record it has made.

In reviewing these facts, it occurs to me that there is danger when an eminently successful institution has been doing a great work for some time, that the rising generation may not realize the conditions that demanded its organization and may not fully appreciate the benefits being directly and indirectly received.

Man in all ages has been a social being, and the influence of our Association along this line should not be underestimated. A large amount of encouragement and help come to us from meeting at stated intervals and talking over our work, and, whether we realize it or not, it is a great privilege to know intimately the leading teachers of secondary school physics in New England. Our meetings at Groton, Tufts, Fairhaven, Worcester, Hartford, Providence, and a score of other places have been full of good fellowship. Such excursions as the trip to the Waltham Watch Factory or the Athæneum Press, in addition to their educational value, furnish most excellent chances for us to become acquainted and enjoy one another. We have a great many fraternal organizations, but I must confess that I can think of none in which the returns are so great in proportion to the time and money expended.

The Eastern Association, founded and maintained by men of sterling worth, has always been a leader in its field, and let us cherish this spirit of good fellowship until it shall be considered, more even than it is today, an honor and a privilege to be one of its members.

Our Association is of great value to a teacher of physics during the early years of his teaching. Its publications, discussions, and older members furnish a field from which it is possible to reap the benefit of years of experience which may place a man on a firm foundation at the very start. The benefits are not limited to those who attend the meetings, for associate membership makes it possible, at a comparatively small expense, for a teacher in the more remote portions of New England to keep in touch, through our excellent reports, with what is being done. He may also take advantage of special offers in the purchase of magazines and may consult by letter with members of the Association upon important points. It seems to me that a live, progressive

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teacher can ill afford to overlook the decided advantage of membership in this Association, and that a great deal of good would result from the increase of our associate membership list. This could best be accomplished, probably, through the efforts of individual members who are willing to work to this end.

This opportunity to speak of the noble service rendered continually by the older members of this Association should not be allowed to pass. They have given freely of their time and energy in order to assist worthy fellow teachers and to elevate the plane of teaching in general. Personally, I feel greatly indebted to these men for their great courtesy and helpfulness. After years of service in the Association, it might seem that they would get little that is really new out of attending these meetings, but fortunately men of such character are working for what they can give rather than what they can get. The Association needs men of such ripe experience and we want them to feel that we appreciate their efforts. Several of our members have become heads of great schools and as such are particularly able to be of assistance to the Association. Our honorary list furnishes a means by which at an opportune time we may honor the most worthy.

The Eastern Association has done much to bring the teachers of college and secondary school physics together. There is still a great field along this line, for certainly these teachers in every possible way should co-operate for the greatest appreciation and development of science.

The Eastern Association of Physics Teachers is a vital force for good, and let us work to extend its usefulness to the greatest psssible extent.

Following this the discussion of the topic, "The Scope and Content of a Physics Course in Secondary Schools" was dealt with. This discussion, which was mainly brought up for the purpose of furnishing material for the Committee on "Requirements in Physics" to use in drawing up a report, brought out many and varied opinions as to how the subject should be taught. Inasmuch as it was deemed best that the information thus obtained should first be submitted to the committee for consideration, it has been omitted from this report, but will appear in condensed form in the report of the committee.

ALFRED M. BUTLER, Secretary.

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PROGRAM OF THE SIXTY-FIRST MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, March 2, 1912

at Massachusetts Institute of Technology

Morning Session, Room 8, Engineering Building C

9.45 A. M.
Meeting of Executive Committee.

10.00 A. M.
Business.
Annual Report of the Secretary.
Annual Report of the Treasurer.
Reports of Standing Committees:—
On New Apparatus. Homer W. Le Sourd, Chairman.
On Magazine Literature. Francis R. Hathaway, Chairman.
On Current Events in Physics. Francis E. Mason, Chairman.
Election of New Members.
Election of Officers.

10.30 A. M.
"Pyrometry." Dr. H. C. Hayes, Harvard University.

11.15 A. M.
"Preparation in Physics for Entrance to the Institute." Professor William J. Drisko, Massachusetts Institute of Technology.

12.00 M.
Luncheon, with visit to laboratories if time allows.

Afternoon Session

1.15 P. M.
Inspection of the Printing Plant of the Christian Science Monitor, followed by an inspection of the heating and ventilating systems of the Church.

3.15 P. M.
Inspection of the ventilating and ice-producing systems at the Boston Arena.

A pair of bifocal eye glasses in folding case and an eyeglass case were found in the astronomical laboratory after the last meeting of the Association. These may be obtained from the Secretary. Also a Fownes glove left in Engineering Room C is in the hands of the Secretary.

The number of reports of following meetings at present in the hands of the Secretary is very low, and if any members have extra copies, they will do a great service in sending them to the Secretary—52, 44, 43, 42, 40, 38, 32, 31.

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MORNING SESSION.

The meeting was called to order by President Griswold.

The first business to come before the meeting was the annual report of the Secretary, which follows:

REPORT OF THE SECRETARY.

There have been three regular meetings of the Association, as follows:

Saturday, March 25, 1911, at Tufts College;

Saturday, June 3, 1911, at Groton School;

Saturday, December 2, 1911, at Harvard University, followed by the annual smoker at the City Club.

Besides these three regular meetings, on Friday evening, April 18, 1911, at the Parker House, Boston, there was a special meeting held jointly with the New England Association of Chemistry Teachers, in the form of a banquet to Dr. Svante Arrhenius of Stockholm, Sweden. At this meeting, speeches were made by Dr. Arrhenius, Mr. C. S. Griswold, the presiding officer, Mr. F. C. Adams, Dr. Lyman C. Newell, Dr. G. S. Forbes, and Dr. W. F. Boos. The banquet was well attended by a large number of the ladies and men of the two Associations.

At our regular meetings addresses and lectures have been delivered by the following men, not members of the Association at the time: Prof. Harvey N. Davis, Prof. R. W. Wilson, and Prof. H. W. Morse, all of Harvard University; Mr. S. Warren Sturgis, Mr. H. L. Crane and Reverend Sherrard Billings of Groton School, Dean Gardiner C. Anthony of Tufts College, and Dr. Arthur Amadon of Boston.

The three meetings of the year have been specialized as to subjects discussed, covering aeronautics, sound and light, in order. This method has seemed to meet with favor.

One Active and seven Associate members have resigned, one Active member has changed to Associate, and one from Associate to Active.

The present membership consists of eighty-four Active, seventy-six Associate and three Honorary members, an increase in all of ten over last year.

The attempt on the part of Mr. N. Henry Black to arrange for a Lowell Course on Heat failed because of too few signifying an intention of taking it if offered.

Respectfully submitted,

ALFRED M. BUTLER.

This was followed by the report of the Treasurer:

ANNUAL REPORT OF THE TREASURER.

RECEIPTS.

To balance March 25, 1911 ..... $ 71.13

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To dues	316.00
To dinners and lunches	57.00
To subscriptions to School Science	88.50
To subscriptions to Scientific American and Supplement	46.40
To subscriptions to Technical World	5.00
To subscriptions to Popular Electricity	15.60
To subscriptions to Popular Mechanics	10.00
To subscriptions to National Geographic Magazine	6.00
To subscriptions to Electricity and Mechanic	1.90
	$617.53

EXPENSES.

By paid for printing	$183.75
By paid for postage and express	36.50
By paid Secretary	30.00
By paid for dinners and lunches	73.80
By paid for School Science	88.50
By paid for Scientific American	46.40
By paid for Technical World	5.00
By paid for Popular Electricity	15.60
By paid for Popular Mechanics	10.00
By paid for National Geographic Magazine	6.00
By paid for Electricity and Mechanic	2.00
By balance March 2, 1912	119.98
	$617.53

Respectfully submitted,
PERCY S. BRAYTON, Treasurer.

The report of the Committee on New Apparatus was as follows:

REPORT OF NEW APPARATUS COMMITTEE.

Homer LeSourd, Chairman.

Mr. Desper exhibited and explained the Meker gas burner. The burner gives a silent flame but one that is hotter in its coolest part than any part of the Bunsen burner flame. A chart was shown which gave the shape of the flame, and Mr. Desper demonstrated the heat secured by melting a copper wire of Number 16 gauge. The burner costs about $1.50, if imported duty free. Bausch & Lamb, and also the Scientific Materials Co. of Pittsburg sell these.

Mr. Miller presented a large working sectional model of slide valve engine with link motion attached.

A thermostat on the principle of a compound bar was shown. It is operated by the heat of a small incandescent lamp which is placed near it and connected in series with it. When the current is turned on the lamp lights, heating the compound bar with conse-

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quent bending away from the contact and thus breaking the circuit and putting out the light. When the light goes out the compound bar cools immediately closing the circuit and making the lamp light again. The thermostats cost about one dollar and can be had at any electrical supply company.

Mr. Packard presented an expansion apparatus to show the force of expansion or contraction of a rod when heated and cooled. There is a steel bar held securely in a heavy frame, at one end by a nut, at the other by a cast iron pin through it. As the bar expands the force shears off the pin, causing the pointer to jump upwards. A replacing of the pin in another hole results in a repetition of the shearing on contracting.

Several slides showing different kinds of snow crystals were thrown on the screen. Also a slide of a regulator for vapor heating.

Cooling by expansion can be shown by the small "Sparklet Bulbs" containing liquid carbon dioxide under several atmospheres pressure. Mr. LeSourd showed a device for opening these with one blow of a hammer. A block of wood has a hole bored in it for holding the bulb mouth upward. To this block is attached the running gear of a roller skate, the axle of this acting as a plunger. The lower end of this plunger is sharpened and rests on the cap of the bulb. The rush of gas from the bulb reduces the temperature to such an extent as to give a coating of frost on the outside.

Mr. Boylston explained a method of finding the volume of carbon dioxide in one of these bulbs by placing the releasing device in a large bottle and leading the gas out of this into another jar and then into a water-displacement tank.

The effect of pressure at the melting point of ice may be demonstrated by means of a chilled steel cylinder two inches in diameter and eight inches long. A hole bored along the axis of this is threaded for its entire length and two steel bolts each five inches long are carefully threaded for their entire length to make a tight fit in the cylinder. About one inch of distilled water is placed in the cylinder and a small bicycle ball is placed in the water. If the bolts are screwed down to just touch the water and the entire cylinder placed in a freezing mixture, ice will form if the pressure is reduced by unscrewing the bolts. Sufficient pressure can be applied with wrenches to melt this ice, and the melting and freezing may be then carried on several times. When the cylinder is shaken the sound of the bicycle ball tells when the ice is melted.

Often the mercury column of the Waterman tube becomes broken by jarring. This may be restored by inserting a slender glass tube into the mercury and through this the air bubble will escape. The slender tube may be made by heating and drawing out a one-fourth inch glass tube until it becomes very thin.

One pound of coal contains energy enough to lift one hundred

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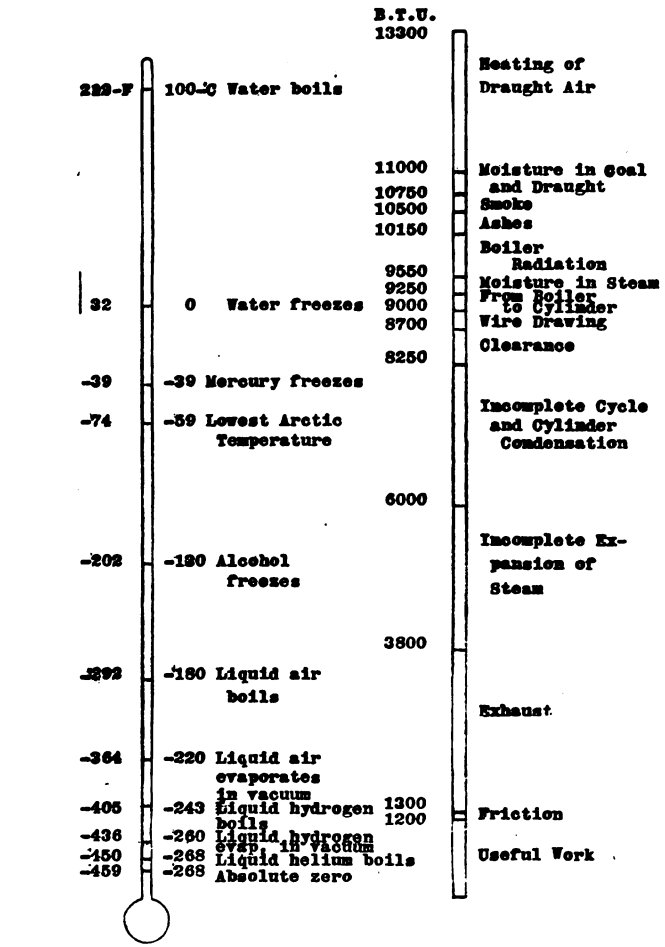
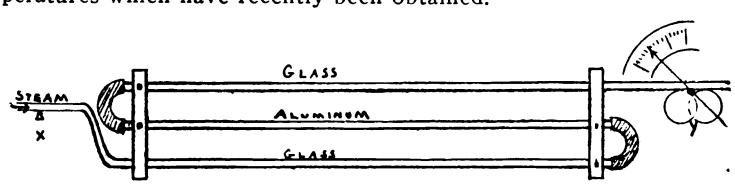
pounds twenty miles. But a small percentage of this energy is available in a steam engine. A chart about seven feet long divided to show the various losses in furnace, boiler, piping, cylinder and engine friction gives an idea of the relative importance of these losses.



A home-made chart of this kind may also be drawn to illustrate the very low temperatures and another for very high temperatures which have recently been obtained.



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Mr. Cowen showed an ingenious device to be used with parts of the Cowen Linear Expansion apparatus, for showing the principle of the gridiron compensation pendulum. It consists of two glass tubes and one aluminum tube. The aluminum tube is connected by rubber tubing to the glass tubes, one at each end. At each end of the aluminum tube a block is securely fastened. The glass tube connected to that end of the aluminum one is also fastened to the block at that end. The free end of one glass tube rests on the axle to which is fastened the pointer, and the free end of the other rests on a fixed support. Any change in length between the two supports will turn the pointer. If steam is passed through, the glass tube, receiving it first, will show an increase in length, but when the aluminum tube receives the steam, expanding in the operation, the pointer returns to its original position.

The report of the Committee on Magazine Literature follows:

REPORT OF COMMITTEE ON MAGAZINE LITERATURE.

(December, January, February.)

Francis R. Hathaway, Chairman.

Electrical World. December 23, 1911. "Experiments with Electrification During Growth of Garden and Greenhouse Plants."

December 30, 1911. "Protection against Lightning" (Editorial). "Wireless Telegraphy on the Atlantic Coast of United States," by J. L. Charlton.

February 10, 1911. "An Electrophysical Explanation of Gravitation," by A. C. Crehore, Ph.D. (rather advanced, involving calculus).

February 17, 1911. "Recent Experiments in Wired Wireless Telegraphy."

Popular Electricity. December, 1911. "Mr. Edison's Impressions of Europe," by W. H. Meadowcroft. "The Founders of the Electrical Industry," by George Frederic Stratton.

January, 1912. "Turbines of Today and Yesterday." "The Founders of the Electrical Industry," by George Frederic Stratton.

February, 1912. "Electrical Vehicles for Business and Pleasure," by W. C. Jenkins. Part 1, "Historical and General Facts Concerning Electrics."

March, 1912. "Some Secrets of Electrical Stagecraft," Part 1, by T. J. Newlin. "Electrical Vehicles for Business and Pleasure," by W. C. Jenkins. Part II. "Things to Know about Vehicle Batteries." "Life of Storage Battery," by Frank M. Ewing.

Popular Mechanics. February, 1912. "Bringing the Flying Machine Down to Earth," by Victor Longheed.

March, 1912. "The Fallacy of the Dirigible," by Victor Longheed. "Remarkable Weather of 1911." "The Effect of the Combustion of Coal on the Climate." "What Scientists Predict for the Future," by Francis Molena. "The Wonders of Light," by

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J. Gordon Ogden, Ph. D. "The Nature of Light and How Light Travels."

Science. December 15, 1911. "How a Falling Cat Turns Over in the Air," by Prof. W. S. Franklin.

December 29, 1911. "Recent Progress in Spectroscopic Methods," by Prof. A. A. Michelson.

January 19, 1912. "Is Science Really Unpopular in High Schools?", by Prof. Willard J. Fisher.

January 5, 1912. "The Work of the Electrical Division of the Bureau of Standards," by Dr. Edward B. Rose.

Scientific American. December 16, 1911. "Some Locomotive Curiosities" (interesting illustrations of old forms), Herbert T. Walker.

December 23, 1911. "Sir P. J. Thompson, the Great English Physicist," by Prof. P. Phillips. Destruction of the Maine Explained."

December 30, 1911. "A Laboratory for Manufacturers: A German Scientific Institution That Tests a Manufacturers' Raw Material and Products and Gives Scientific Advice," by Waldemar Kaempffert.

January 6, 1912. Motor number, containing articles interesting to autoists, as "Making the Starting Crank Obsolete," "New Accessories of the Automobile," "The Motorcycle of 1912."

January 13, 1912. "Biographical Sketch of Francis Bacon Crocker, Inventor and Educator" (of Crocker-Wheeler Co.). "Antarctic Expeditions" (five), briefly described.

January 20, 1912. "The Romance of Echoes"; interesting cases described. "The Kinemacolor Process: Moving Pictures in Their Natural Colors Photographically." "Seeing One's Self Talk" (a curious invention).

January 27, 1912. "The Maine Explosion No Longer a Mystery." "First Trans-Atlantic Continental Railroad in South America, from Atlantic to Pacific," by F. C. Coleman. "A Laboratory Experiment: An Easily-Made Vacuum Apparatus," by Russell Edson.

February 3, 1912. "Across the Atlantic by Aeroplane," by James V. Martin.

February 10, 1912. "The Model Boat, 'Froude,' used for Scientific Experiments by the Massachusetts Institute of Technology," by John Ritchie, Jr. "The Curtiss Flying Boat; A New Hydro-Aeroplane." Frank T. Searight.

Scientific American Supplement. December 2, 1911. Travelling at High Speeds: A Review of Records in All Fields of Locomotion," I. (See II. in issue of December 9.) "Radio-Telegraphy," II., by C. G. Marconi (begun in November 25 issue). "Starting Up a 30,000 H. P. Generator (of the Turbine Type) in New York City." "The Cost of Power from Sun and from

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Coal," by Frank Shuman. (See also September 30, 1911.) "Power Derivable from Ocean Waves," by Franklin Van Winkle.

December 9, 1911. "Methods of Controlling Steam Engines" (governors), John Davidson.

December 16, 1911. "The Psychology of Light," I., by Prof. R. S. Woodworth. (See also II., III. in issues for December 23 and 30.) "A Great Modern Telescope: the Sixty-Inch Reflector at Mt. Wilson Observatory," by C. A. Chant. "Electric Waves Directed by Wires," by Major G. O. Squier, Ph. D.

December 30, 1911. "The Physiological Aspect of Ventilation" (influence of imagination pointed out), Theodore Hough.

January 6, 1912. "The Marine Steam Turbine from 1894-1910," I. (II. in issue of January 13), by Sir Charles A. Parsons. "The Manufacture and Performance of the Edison Storage Battery," by Howard Lyon.

January 13, 1912. "Automatic Telephone Exchange Systems," I. (see II. and III. in issues of January 20 and 27), by W. Aitken. "Professors and Practical Men: Report of Prof. Smithell's Address Before Society of British Gas Industries."

January 27, 1912. "An Easily-Constructed Testa Coil," Allan S. Dana.

February 10, 1912. "Scientific Progress and Prospects," address by Pres. A. A. Campbell Swinton before the Roentgen Society.

February 17, 1912. "Aeroplane Efficiency: Condensed Theory as a Guide for Practical Construction," by Algernon E. Berriman. "The Application of Pyrophoric Alloys" (from cigar-lighter to miner's safety-lamp). "The Production and Identification of Artificial Gems," I., by Noel Heaton, F. C. S. (See II. in next issue.)

February 24, 1912. "Sir William Ramsay, Who Has Realized the Alchemist's Dream," by P. F. Mottelay.

School Science and Mathematics. December, 1911. "The Purpose and Method of Experimental Work in Physics," S. E. Coleman. "An Open Book Test" (in Physics), by A. P. Andrews. "Rotation of a Magnet Pole" (experiment), by H. E. Hadley.

January, 1912. "The Removal and an Explanation of Difficulties with the Volume Coefficient of Expansion Apparatus," Albert E. Hennings. "Gibson's Acceleration Apparatus," Dell Gibson. "Experiments in Fluid Pressure," H. C. Krenerick. "A Laboratory Exercise to Verify the Laws of Accelerated Motion, for High School Classes," Philo F. Hammond.

February, 1912. "Adaptation of Physics to Different Types of Pupils," S. E. Coleman. "A Momentum Balance." "The Effect of Air Resistance on Falling Bodies," by Carl Kibler and Lewis Linder. "An Electrical Experiment" (a jet of water diverted by an electrified rod), Elmer E. Burns.

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Technical World. January, 1912. "Adventures of the Moving Picture Man," P. Harvey Middleton.

February, 1912. "A Powerful Turbine a Mere Toy" (description of 110 H. P. Testa turbine the size of a hat), Henry Jevons. "One Inventor Who Kept His Own: Description of the Knight Silent Motor," H. B. R. Briggs. "Photographing with Invisible Light (infra-red and ultra-violet), C. F. Craig. "Recent Wright Experiments" (aeroplanes), M. L. Brand.

March, 1912. "Sun-Power to Irrigate the Nile Valley," by Arthur St. George Joyce. "Cooking in Paper Bags."

World's Work. January, 1912. "Mechanical Progress."

February, 1912. "Scientific Progress." "Aerology, the New Science—How It Explores the Upper Atmosphere," by Charles Fitzhugh Talman.

The report of the Committee on Current Events in Physics Follows:

REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

Francis E. Mason, Chairman.

It is impossible to determine the quality of fusion welds (oxy-acetylene or oxy-hydrogen) by mere external examination. A simple chemical test may be applied to welds on iron or steel. Clean a spot with a file or chisel and apply a strong solution of iodine in potassium iodide solution with a hair brush. Any crack or blister will be exposed.

In Germany alcohol is prepared from chicory roots which grow in great quantities near Magdeburg and Brunswick; 100 pounds of the juice by special fermentation yields about 8.4 liters of alcohol.

The action of zinc chloride on cellulose which has been mixed with coarse rock salt turns it into artificial sponge. Special machines form the mass to make it porous. It is especially adapted to filtering drinking water, but can be used for any purpose that the natural product can.

Many cases of infectious diseases, especially diseases of the eye, are reported to have been contracted in swimming-pools, where hundreds of swimmers bathe. Experiments at Yale University show that from 0.3 to 0.5 parts of chloride of lime to 1,000,000 parts of water will effectively purify it. The lime must be used daily. It is so diluted that the swimmers are unaware of its presence.

Professor Engler, director of the Institute of Mineralogy at Berlin estimates the reserve of coal in the earth in 1911 as 3000 milliards of tons. Europe has 700 milliards, United States has 780 milliards. He predicts that coal will last the different nations from 700 to 1700 years. This estimate is more liberal than that of Sir William Ramsay, who recently predicted that the coal supply of England would only last about 175 years.

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The weather observatory at Manilla has issued a special bulletin describing the typhoons of the past summer. There were three typhoons in twenty-two days. The rainfall of the first typhoon was unprecedented. During the first four days the rainfall at Bagnio was 88 inches, of which 32 inches fell during the first day. No similar rain has been officially recorded in any other part of the globe; the next heaviest rainfall was 48 inches in four days, at Jamaica in 1909. For sake of comparison, the total yearly rainfall at Washington is about 43 inches.

Dr. Berthault of Paris has discovered that a surprising variation exists in the cellular density of potatoes. Examination with the microscope shows that edible varieties have small and numerous cells, while industrial varieties have larger and coarser cells. He claims that potatoes of fine flavor have the smallest cells. Those of larger cells should be used for the manufacture of starch.

The recent demolition of an old gasometer at Hamburg has confirmed the assertions of engineers regarding the behavior of iron in concrete. The building was erected in 1852. Its foundations rested upon pillars anchored to iron bars. These bars were embedded in concrete, and upon removal were found wholly free from rust. For nearly sixty years they had retained the characteristic blue color of new iron.

A new metal-filament lamp has been produced in Belgium that is said to give a much more efficient light than ordinary electric lamps. This is due to the fact that the filaments are arranged in the form of a small square gridiron, fixed horizontally in the centre of the globe and capable of standing any amount of vibration. The light is thrown downward so that the illumination is concentrated directly underneath. Tests show that this kind of lamp gives fifty per cent. more light than an old style lamp of the same candle-power..

Recent experiments at the Massachusetts Institute of Technology show that water may be made to solidify in five different kinds of ice, each of which at certain temperatures and pressures changes from one kind into another with explosive violence. One kind, "ice 2," requires a very low temperature and great pressure to keep it from changing into ordinary ice. Another kind will stay frozen at summer heat provided it be under a pressure of 20,000 atmospheres. It is probable that some of these kinds of ice were never in existence outside the experimenters' hydraulic press.

The most powerful wireless station in the world has been completed by the Marconi Company at Coltano, Italy. Messages have been sent to Clifden, Ireland, to Glace Bay, Nova Scotia, and will soon be sent to Buenos Aires. The distance from Cottano to Buenos Aires is approximately 7000 miles.

There is a widespread and increasing use of electrical devices

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for measuring high temperatures in the various technical industries. These measure, within five degrees, the temperature as high as 2000 °C. The tempering of steel, for instance, need no longer be guesswork, but can be done under conditions that guarantee uniformity of product.

The following new members were elected to Associate membership, having been duly presented by the Executive Committee:

Dr. George W. Pierce of Harvard University, Cambridge, Mass.

Mrs. Helen W. Farrell of the Concord High School, Concord, Mass.

On motion of Mr. Peterson, seconded and carried unanimously, the Secretary cast one ballot re-electing the following officers for the year 1912-1913:

President, C. S. Griswold, Groton School.

Vice-President, F. H. Cowan, Girls' Latin School, Boston, Mass.

Secretary, A. M. Butler, East Boston High School.

Treasurer, P. S. Brayton, Medford High School.

Executive Committee: F. R. Miller, C. H. Andrews, F. M. Greenlaw.

Dr. H. C. Hays of Harvard then addressed those present on the subject of

PYROMETRY.

Pyrometry deals with the measurement of the intensity factor of the heat energy that a given mass contains. This factor is called the temperature.

The temperature of the mass in question is seldom taken, but that of a body supposed to have the same temperature as that of the mass is measured. The law of heat exchange makes this possible.

Temperature, being intangible, is always measured in terms of its effects, inasmuch as every physical property of a body, except its mass, varies with its change in temperature.

Laws may be divided into natural and empirical, both of which express a relation between cause and effect, and can be expressed mathematically by an equation of the form

$$E = f(c)$$

where E is the numerical value of the effect and c is the corresponding value of the cause. If f(c) is definitely known to within the accuracy of the experiment, the equation expresses a natural law, but if f(c) is only approximated to by taking a few terms of a series, then it is termed an empirical equation.

The natural law connecting temperatures and physical property is known in but two cases: namely, Charles' Law and the Laws of Radiation.

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Temperature scale must be defined through a natural law. Charles' Law is the one used, and the temperature scale so defined simplifies the expressions in the mathematical treatment of thermodynamics. The same temperature scale would be reached if it were defined by any other natural law involving temperature.

Instruments that are used for measuring temperature, and are based on a relation between temperature and volume, are called thermometers; and, since the expanding substance is usually a gas or a liquid, it must be enclosed in glass. Since glass softens at temperatures above 500° Centigrade, that is about the limit to which these instruments can be used.

Instruments that are based on a relation between temperature and any other physical property than volume, are called pyrometers. Since these instruments can be used to measure temperatures far above 500 Centigrade, pyrometry is thought of as dealing with the measurement of temperatures above 500° Centigrade. Such an idea is meaningless, as quartz thermometers can be used to nearly 800 Centigrade, and pyrometers can be used to measure very low temperatures.

RESISTANCE PYROMETERS.

Only empirical relations between resistance and temperature are known, consequently the temperature as determined through this relation will have to be corrected to get the temperature as defined by the gas thermometer.

Of this type of pyrometer, the Callander, devised in 1886, in which the fact that Platinum wire offered an error of not more than one part in 10,000 if it is well seasoned and kept free from contaminations, is the best known.

The formula for the temperature calculation follows:

$$T_{\text{desired}} = 100\,\frac{R_T - R_{\text{zero}}}{R_{100} - R_{\text{zero}}}$$

The advantages of this type of pyrometer are: convenience of size and shape, and use at great distances. The disadvantages: that they are not constant if in the presence of any sort of contamination, solid, liquid, or gaseous; that they require accessories, a Wheatstone bridge and battery, or a potentiometer and battery.

THERMO-ELECTRIC PYROMETERS.

(Le Chatelier form.)

Here the contact potential produced in two unlike metals, hot and cold junction, depends on the temperature.

Following are several thermo-couples used:

Copper and constantin, or German-silver;

Platinum and nickel;

Platinum and a ten per cent. alloy of iridium, or rhodium with platinum.

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With such couples, combined with a constant temperature bath, and a potentiometer or sensitive voltmeter, an E. M. F. of about ten millivolts is obtained with 0° Centigrade at cold junction and 100° Centigrade at hot junction.

The advantages are: minimum of apparatus and size; not greatly affected by gases; can be rehabilitated by long heating; can be used to temperatures of 1450° Centigrade.

RADIATION PYROMETERS.

The temperature of bodies may be determined by determining the amount of radiant energy that they emit, either in the form of light radiation or the longer infra-red waves that are studied by their thermal effects. For estimating temperature in this way use is made of the so-called laws of radiation.

A number of excellent pyrometers are based on the measurement of the photometric intensity of the light emitted by incandescent bodies. These measure the intensity of the red radiations, since it is difficult to compare the total radiation as the predominant color shifts toward the violet when the temperature is increased; also, the red light appears first, so the instrument can be used for lower temperatures.

This would appear to be an ideal method as the intensity of the light emitted varies rapidly with the temperature, but the intensity of the light emitted is not a function of the temperaure alone. It depends on the character of the surface and on the composition of the body. The intensity of the radiation from iron at 1000° Centigrade is many times greater than that emitted by magnesia or polished platinum at the same temperature.

Kirchoff's "Black Body" is of fundamental importance in dealing with the subject of radiation, as the radiation from such a body is independent of everything but the temperature of the body.

The radiation from such a body is the same as that inside an enclosure the walls of which are at the same temperature as the body in question. Such conditions can be obtained and are used for the calibration of many radiation pyrometers.

Pyrometers so calibrated give "black body" temperature.

There are errors that a pyrometer so calibrated might lead to. Iron and porcelain at 1200 would be found 1140 and 1100, respectively. Such a pyrometer is useful because, in general, black body conditions can be approximated and because the instrument gives consistent results.

METHODS OF OPTICAL PYROMETRY.

1. Color estimation.
2. Photometric-LeChatelier, Fery, Wanner, Holborn-Kurlbaum, and Morse.

All except Holborn-Kurlbaum make use of Wien's distribu-

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tion law, and since this is linear, require but two temperatures for calibration. They can be used for the highest attainable temperatures.

3. Ratio of the intensities of two wave-lengths. Corva, 1878.

4. Upper limit of the spectrum. Hempel. Results are crude.

5. (a) Maximum energy in the spectrum. This is not practical, as the curves show. It also requires delicate apparatus. (b) Magnitude of the maximum energy. This requires the same elaborate apparatus.

6. Energy of total radiation. This not practical as too complicated apparatus is required.

A complete discussion of these instruments may be found by those who are interested, in Reprint No. 11 (From Bulletin of the Bureau of Standards, Volume 1, No. 2) Optical Pyrometry. This may be secured from the Bureau of Standards, Department of Commerce and Labor, Washington, D. C.

Professor William J. Drisko, who has charge of the entrance examinations in Physics at the Institute, then spoke informally on the

PREPARATION IN PHYSICS FOR ENTRANCE TO THE INSTITUTE.

As an introduction, Professor Drisko briefly outlined the work in Science and Mathematics as given to all students during the first two years of their course, no matter which one, of the many offered, it may be.

During the first year all take the course in Chemistry, consisting of lectures two hours and recitations two hours, and laboratory work six hours a week.

During the second year all take Physics; three hours of lecture, two of recitation and one afternoon of laboratory. Thirteen weeks are devoted to Mechanics, which is considered vital for what follows. The three lectures are devoted to demonstration and the two recitations to simple problems of application of the principles as met in engineering work. The great fault noticed among the students coming up for examination has been that the Physics given them in the secondary schools has been during the early years of their course, when their minds were less mature, and they thus forget much that has been taught them. The best pupils have been those who took Physics late in the high school course.

A good preparation should include an accumulation of facts, the simple laws, very little theory, and as many **simple** practical applications as possible, e. g. explanation of **simple** illustrations of the laws of motion, centrifugal force, momentum, inertia, energy transformation, heating systems of buildings, horse power of a cook stove, and of a hod-carrier. Many boys, highly recommended from their secondary schools, fail to make good in the Institute because they have spent too much time in the study of applications, the understanding of which is out of their reach. They lack training

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in the fundamentals, which are far more important. Of the two, the spectacular and the fundamentals, the former should be avoided, if one is to be sacrificed.

To take specific cases, the following are some that are not clearly understood by many: the laws of motion, meaning of action and reaction, momentum, mass and weight, barometers (what they measure, how and why reduce to zero), acceleration, temperature and heat difference, reason for fixed points on thermometer scales.

The teaching of the absolute system is to be discouraged. The metric system should be taught only in an elementary way. Acoustics should be only touched upon, if at all. In heat, the meaning of temperature (as contrasted with heat), specific heat and latent heat should all be emphasized. In optics the laws of reflection and refraction, the study of mirrors and lenses and simple optical instruments should be taught thoroughly. (All students seem very well prepared in Optics.)

In Electricity great stress should be put on the fundamental facts in electrostatics and magnetism, that they may not be confused with each other and with current electricity. Pay more attention to the fundamentals and less to the superficial knowledge of dynamos. motors, electric lights, telephones and wireless.

To sum up, lay the greatest stress on a grasp of the fundamental facts and principles and the simple applications in these, bringing home the facts by means of simple problems wherever possible.

The morning session closed with a unanimous vote of thanks to Dr. Hayes and Professor Drisko for their highly instructive talks, and to the Institute for the use of the lecture room.

AFTERNOON SESSION

Christian Science Publishing Company and Christian Science Church

The first part of the afternoon was spent in an inspection of the Publishing House, where the various Christian Science Publications, including the "Christian Science Monitor," are printed, and of the church, with its complete heating and ventilating systems and its magnificent organ, to hear which an opportunity was given to all present.

Each member present was presented with a tasteful souvenir printed by the Publishing Company, appropriate to the occasion, with a fine lithograph picture of the church and a description of its heating and ventilating features, which follows:

The steam is furnished from a battery of six eighty-horse power, return tubular boilers located in the Publishing House. The further equipment consists of the Webster vacuum system in connection with the Johnson Service of thermostats and diaphragm valve regulation, each thermostat controlling the supply of steam to one or more diaphragm valves and radiators. The vacuum pump

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creates a partial vacuum, drawing the condensation away from radiators or coils, thereby allowing steam at a low pressure to be circulated easily and quietly throughout the system.

The five large fan blowers in the church have a capacity of about 80,000 cubic feet of fresh air a minute. Each of these fans is provided with an electrically driven, centrifugal pump, furnishing a supply of water which forms two curtains of dense spray. Through this water the air is forced on its way to the auditorium and all dust is thus removed from the air and the requisite humidity secured. In summer the air is cooled by the water curtain and by use of ice in the air intakes. The air is forced into the auditorium through the legs of the pews and into open spaces under them, thus giving a uniform distribution.

The Church has 8,700 square feet of direct and 4,800 square feet of indirect radiation. The Publishing House has 8,200 square feet of direct radiation.

All electricity is bought from the Edison Illuminating Company for both buildings. The total connected electric lighting and power load in the Church is 250 kilowatts and in the Publishing House 225 kilowatts.

In both buildings the dirt and dust are removed by a large corps of janitors and the use of portable vacuum cleaners.

The afternoon session ended in a visit to the Arena, with an inspection of its ventilating and ice-producing systems, and the curling rink.

The ventilation of the Arena is secured by suction fans which draw off the warm air from the upper part of the skating area through large pipes that have frequent openings.

The ice-making is done by the ammonia-brine process. Ammonia is compressed to 140 pounds pressure and is then condensed in pipes, over which city water flows. This ammonia is then expanded in pipes surrounded by brine, thus cooling to a temperature of 0° F., if the expanded ammonia is at 15 pounds pressure. The temperature of the brine is kept between 14° and 20° F. This brine is pumped into the pipes which stretch across the floor of the Arena, at a distance of about three inches from each other, and about three-fourths inches from the granolithic floor of the skating space. Water covers the pipes and an ice surface about four inches thick is built up by degrees. The brine returns to the brine tank about 3° cooler. Three times a day during the skating season the ice is scraped and a thin layer of hot water put on it. The hot water melts the fine particles of ice left behind after the scraping, and thus insures a hard, smooth surface.

Owing to leakage, fresh ammonia must be added from time to time from tanks of compressed liquid ammonia. During the present season about 100 pounds of liquid ammonia have had to be added every month.

ALFRED M. BUTLER, Secretary.

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REPORT OF THE SIXTY-SECOND MEETING

OF THE

Eastern Association of Physics Teachers

at the Charlestown Navy Yard

Saturday, June 1, 1912

Morning Session.

9.30 A. M. Meeting of Executive Committee.

10.00 A. M. Business Meeting in the Armory.
Reports of Standing Committees:—
On New Apparatus. John C. Packard, Chairman.
On Magazine Literature. G. G. Bulfinch, Chairman.
On Current Events in Physics. F. H. Hadlock, Chairman.
On New Books, Clarence M. Hall, Chairman.
Election of New Members.

10.30 A. M. "The Navy Yard." Commander S. V. Kittell, Inspector of the Yard.

11.00 A. M. "The Battleship Virginia." Commander E. T. Pollock.

11.30 A. M. Demonstration of the Gyroscope Compass.

12.00-1.00 Lunch.

Afternoon Session.

1.00 P. M. Inspection of the Battleship Virginia.

3.00-5.00 P.M. Inspection of the Dry Dock, Machine and Chain Shops, Rope Walk, and Wireless Station.
Opportunity will also be given for inspection of the Constitution and other historic features of the Navy Yard, as well as the other battleships, torpedo boats, etc., that may be in the yard at the time.

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MORNING SESSION.

The meeting was called to order by President Griswold, who at once called on Mr. Packard to report for the Apparatus Committee.

REPORT OF COMMITTEE ON NEW APPARATUS.

Mr. Parish showed a direct reading specific gravity balance for objects heavier than water. This consisted of a balance with fixed pivot and unequal arms. At a definite point to one side was attached a double basket arrangement, the lower basket being always immersed in water. On the other arm was a movable scale pan. The object to be examined was placed in the upper basket, and balanced with weights placed on the scale pan, the latter being slid way out to the end of the arm. The object was then placed in the lower basket, and the scale pan then slid in towards the pivot until again a balance was secured. The ratio between the distance this was moved in and the whole length of the arm was the inverse of the specific gravity.

Mr. Hall showed a piece of apparatus for four forces in one plane at right angles to each other, that could be used by a single student. It consisted of a small square board with the numbered holes, that could be placed inside a brass frame. Rubber bands were fastened, one end to the peg on the board, and the other to a slip ring on the wire frame. By proper sliding of the rings, the bands could be brought into proper relation, and the force on each then successively determined by a spring balance passed through each ring.

Mr. Packard then showed the triple range volt ammeter, advertised in the Weston Catalogues lately sent to members. The ranges were: Ammeter 30, 3, 1.5 amperes; voltmeter 150, 15, 1.5 volts. There was a push button for the voltmeter. The case was of hard rubber.

The report of the Committee on Magazine Literature, G. G. Bulfinch, Chairman, follows:

REPORT OF COMMITTEE ON MAGAZINE LITERATURE.

Cassier's. March, April, May, 1912. "Mechanical Appliances on the Panama Canal." Illustrated.

March, 1912. "Is Electric Traction Coming for Maine Line Railways?". I, "The Operation of Steam Railroads by Electric Motors," by J. B. Whitehead; II, "The Electrification of Steam Railways," by Arthur Curran. "Harbor Dredging," by Brysson Cunningham.

May, 1912. "Remarkable Locomotives of 1911," by J. F. Gairns. "Hydraulic Power, Its General Utilities," by Joseph Horner.

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Electrical World. March 16, 1912. "Thickness of Insulation on Wires and Cables." "A Variable-Absorption Screen for Photometric Use and Its Application to Portable Photometers," by H. E. Ives.

March 23, 1912. "New Power Station of the Boston Elevated."

April 13, 1912. "Ultra Violet Energy in Artificial Light Sources." "Effect of Ultra Violet Light on Eyesight." "Highest Voltage Transmission Line in the World" (continued April 20).

April 20, 1912. "Melting Points of Tungsten and Tantulum."

May 4, 1912. "A New Nickel Iron Storage Battery." "Recent Developments in Transmission Line Voltages."

Harper's Weekly. April 13, 1912. "The Enemy in the Depths" (explaining by hydrostatic pressure the cause of the collision between the Olympic and the Hawke).

Popular Electricity. May, 1912. "The Pulmotor." "Some Secrets of Electrical Stagecraft," by T. J. Newlin. Part III, "Electric Vehicles,—for Business and Pleasure," by W. C. Jenkins.

June, 1912. "Phonographs and the Man That Invented Them," by F. P. Stockbridge. "Charles Protens Steinmetz," by F. P. Stockbridge. "Eavesdropping by Science," by E. L. Fox.

Popular Mechanics. April, 1912. "The Wonders of Light," by J. Gordon Ogden. "The Luminiferous Ether, Polarization and Measurement of Light."

May, 1912. "What the World Gains by Discovery of the Poles," by Robert E. Peary. "The Wonders of Light," by J. G. Ogden. "Artificial Light."

June, 1912. "The Wonders of Light," by J. G. Ogden. "Reflection and Refraction."

Scientific American. March 9, 1912. "The Turret Telescope" (a new form of mounting), by Prof. S. A. Mitchell.

April 13, 1912. "Arrhenius and His Electrified Children—A New Use for High-frequency Currents," by J. B. Huber.

April 20, 1912. "Girdling the Globe by Wireless—The Navy Chain of Wireless Stations," by Dudley Harmon. "The New Element, 'Niton,'" by Dr. L. K. Hirshberg.

April 27, 1912. "What We Know about Icebergs."

May 25, 1912. "An Aqueduct Two Hundred and Forty Miles Long" (How Steel and Concrete Siphons Will Supply Los Angeles with Water), by B. A. Heinly.

Scientific American Supplement. March 9, 1912. "The Art of Color Photography," by Dr. J. A. Stärcke.

March 16, 1912. "The Self-starting Siphon," by William P. Munger.

March 23, 1912. "Regulation of Radiotelegraphy," by Robert A. Morton, Jr.

April 13, 1912. "A School for Colonial Science" (The Newest

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Departure in German Educational Work), by Dr. Alfred Gradenwitz. "New Seismometers."

April 20, 1912. "Electrolytic Dissociation" (History of the Ionic Theory, sketched by its founder), by Svante Arrhenius. "The Gif Laboratory for Radioactive Examinations."

April 27, 1912. "Industrial Use of Ozone," by F. M. Perkin. Fundamentals I and II. "The Essential Principles of Engineering Practice," by O. Bates (continued in May 4 number).

May 11, 1912. "The Chemistry of Sewage Disposal," by G. G. Nasmith. "How Irrigation Founded a Scientific University" (University of Arizona), by D. A. Willey. "Stereoscopic Vision," by Frederic Campbell. "The Ether" (A Summary of Evidence for and against Its Existence), by P. G. Nutting.

May 18, 1912. "The Present Position of Wireless Telegraphy," by Count George von Arco.

May 25, 1912. "The Photographic Industry—Its History and Development," by Dr. C. E. K. Mees.

School Science and Mathematics. March, 1912, "The Opportunity Now Before Physics Teachers," by J. M. Jameson (Pratt Institute, continued in April number).

May, 1912. "The Test of Efficiency in Teaching Physics," by W. C. Bagley. "A General Science Course of Elementary Physics and Mathematics Combined," by J. C. Gray. "An Apparatus for Both Boyle's and Charles' Law," by C. E. Linebarger.

Technical World. April, 1912. "Canadium—More Precious Than Gold," by Dr. L. K. Hirshberg. "Electricity Makes Flowers Bloom," by E. I. Pratt. "Measuring the Smallest Thing in the World," by R. H. Morton. "Light Without Heat," by E. Bingham and E. Roques. "Bending a Steel Bar with the Little Finger," by Robert A. Sanborn.

World's Work. March, 1912. "Popular Mechanics," by W. H. Miller. "A New Marine Engine." "The Gyroscopic Compass." "The Tesla Turbine," by F. P. Stockbridge.

June, 1912. "Wireless and the Titanic" (an authorized interview with Guglielmo Marconi, inventor of wireless telegraphy).

The report of the Committee on Current Events in Physics, F. H. Hadlock, Chairman, follows:—

REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

An interesting example of the employment of wind power for the generation of electricity is being given at Bromyard, Worcestershire, England. A plant has been installed that is provided with a wind turbine for electric driving. The wheel is 24 feet in diameter and is mounted upon a steel tower 75 feet high

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The plant furnishes current for lighting and power for running machinery.

The largest Diessel engine yet built for stationary work is that of 2400 horse power, manufactured by Sulzer Bros. of Winterthur, but it is now stated, however, that an order has been placed with the same firm for four 4000 brake-horse-power engines, destined for electrical driving in Chile. These will be of the six-cylinder type, working on the two-cycle principle.

A French chemist, Dr. Jaubert, has recently achieved admirable results by a new process for making hydrogen. This consists in mixing ferro-silicon with caustic soda and calcium hydrate to form a powder which he terms "hydrogenite." This is compressed into briquettes which are easily portable. They are combustible but non-inflammable, burning when ignited without flame. When they are burned the silicon of ferro-silicon unites with the sodium, calcium and oxygen of the calcium hydrate and the caustic soda, while the hydrogen is isolated. It is calculated that 1 kilogram of the compound will yield 0.33 cubic meter of gas. This discovery ought to materially assist the proposed attempts at ocean-crossing by means of dirigible balloons.

Logs can now be seasoned by electricity. A new process, in which the logs are set on end in a solution of soda or zinc sulphate, has been experimented with successfully. Ring-shaped electrodes are partially driven into the top ends and the space inside the rings filled with the same solution as is used in the tank. These rings are connected to one side of a direct current and the tank to the other. The sap is driven out by the action of the current and the progress of the work may be told by watching an ammeter in circuit.

Mme. Curie has now in use in her laboratory a special type of storage battery. It is constructed to give a very steady current for use in her radium experiments. The voltage, which may be varied, runs as high as 1700 volts. This requires a great number of cells. Each cell consists of one positive and one negative element in a large test tube. These are mounted in a cabinet. It is claimed that the voltage is very steady, never varying 1-100 of a volt in a 1000.

It has long been known that the resistance of the common metals increases somewhat when the metal is heated. Prof. H. Kammerlingh-Onnes of the University of Leyden recently succeeded in liquefying helium and reached a temperature within 6° of absolute zero. There he found that the resistance of pure quicksilver was but 1-100000 part of what it was at 32° F. In other words, the resistance of metals seems to be a quality which may be said to be practically "frozen out" when the temperature is greatly lowered.

In order to accurately measure the velocity of all portions of

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a stream, a current meter, called the Price meter, is being extensively experimented with by the U. S. Geological Survey. It is held under the water wherever the velocity is to be determined. A series of vanes keep the head pointed up stream. The moving part comprises a little vertical shaft carrying four arms with cups on the ends. The rapidity with which these cups revolve is proportional to the velocity of the water. The instrument is calibrated so that the operator knows that a certain number of revolutions per minute represents a flow of a definite number of feet.

The pulmotor is the latest step of science in meeting death caused by asphyxiation, electric shock or poisoning. A sort of face cap, with a soft rubber rim is placed over the mouth and nose of the patient. It is connected by two tubes to a box which contains the apparatus. In the box is an iron cylinder 3 1-2 inches by 21 inches, which contains oxygen at a pressure of 2800 pounds. By the operation of valves, bellows and pistons, oxygen, mixed with air, is forced into the patient's lungs and drawn out again. This is repeated several times a minute and in fifty per cent. of the cases is successful.

Mr. Clarence M. Hall then reported for the New Book Committee.

REVIEW OF NEW EDITION OF CARHART AND CHUTE'S "FIRST PRINCIPLES OF PHYSICS."

(Published by Allyn & Bacon, Boston.)

"Not many years ago the ideal text-book in elementary physics was little more than a concise, scientific statement of the fundamental principles of the subject, illustrated by experiments and reinforced by numerous problems designed to emphasize the expression of physical relations in mathematical form."

"Attempts have been made to meet the dissatisfaction with this type by presenting many familiar illustrations of the practical application of physics, but with an unsatisfactory treatment of the fundamental principles on which these applications are based. As a result pupils gained few definite ideas."

"The present volume is the result of an attempt to make a book which shall have a strong element of interest and at the same time be so clear and definite in the treatment of principles that pupils may retain some useful acquisitions for daily life and a preparation for college entrance."

The present volume places the Mechanics of Fluids before the Mechanics of Solids, which seems a desirable change from the former editions, although one might prefer to place the more difficult Mechanics of Solids later in the course, when pupils will have had more practice in mathematics in the school.

The exercises and well chosen problems at the end of each

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section are excellent, as is also the introduction of pictures and short biographies of noted scientists.

The order of topics is good and the articles are numbered and printed in heavy type. I note the use of cm^2 and cm^3 for sq. cm and cc.

The applications are described at the place in the text where the principle itself is explained.

It is interesting to note the submarine boat given as an example of the Cartesian diver.

The subject of acceleration is most excellently explained. The dyne is clearly defined.

Principles are italicized and given in equation form also.

The terms "rest" and "equilibrium" are sharply distinguished, and the definition of "component" is especially good.

Some of the experiments are unique, notably that of dropping a penny on which is laid a smaller paper disc, to show that they will fall at the same rate.

Work and energy are made especially clear.

In the subject of Light, a neat explanation is given of refraction and the index is defined, not as a ratio of perpendiculars to a normal, but frankly as the ratio of velocities in the two media.

The wave theory is well developed, but the diagrams are by the ray method, which makes for clearness.

Under Electricity the use of "conductance" instead of conductivity is in line with modern electrical engineering parlance. The use of circular unit and unit foot is excellent, since practical calculations are in terms of these units.

The pictures of actual cells wired up and placed with them, the symbols for that grouping help to fix the principles in mind.

The commercial ironclad form of electromagnet is shown.

The action of a condenser and cause of self-induction are well explained.

The book describes the magnetite and flaming arc light and tungsten lamp, and seems to be written right up to the minute, as shown by the account of radio-activity with which the book terminates. An excellent feature is the appendix of useful geometrical constructions and data tables.

Criticism of the book will be difficult to make, it seems to me, but one may note that on page 17, the authors have given a law for effusion of gases, involving terms which have not been previously explained in the text.

The experimental proof of equality of pressure in all directions at a point in a liquid is not above criticism, as has been shown by Professor Hall of Harvard University, in his book on "The Teaching of Physics."

I had looked for the use of the word "decelerate" to signify

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"negative acceleration," as proposed by Steinmetz of the General Electric Company.

In one problem the expression, "speed per minute," occurs, in place of velocity.

Under Magnetism one notes the absence of the diagrams of molecular condition of magnets.

There is possibly too much theoretical discussion of electrolysis and use of absolute units.

The electrolysis of dilute sulphuric acid is given as if it were water alone being decomposed, although just before, there is a good discussions of ions.

A diagram of connections for an electric bell would be an improvement in the article describing its action.

The Granuve ring armature is not so important as formerly, and might have been omitted.

In conclusion, it may be said that the book is a fine example of the modern elementary physics text, in language, teaching order, interest, and mechanical make-up.

The following were then unanimously elected to membership:

Active.

Mr. Leighton S. Thompson, Roxbury Latin School, Roxbury, Mass.

Associate.

Mr. Fred E. Fish, Deering High School, Portland, Me.

Commander S. V. Kittell, Inspector of the Yard, then spoke on

"THE NAVY YARD."

Ladies and Gentlemen:—I have explained to your good Secretary that I am just a plain sailor, and not a speaker, and therefore I can make very few excuses to you for my poor efforts in this way, except to claim your attention on the basis of my very great respect for the science which you represent and teach. That science, with the kindred one of chemisty—those two together—bear more closely than any other upon our lives, and they are very closely kindred because they are, I believe, really based upon the one great fundamental law of vibration.

Now we of the navy have been in a way connected with physics. We have had representatives in that field. Not many years before the time of my graduation from the Naval Academy, there was a man who graduated from that course who left the navy immediately after his graduation, and who has since that time devoted his life to that great science, and that is Professor Michaelson, of Chicago. He is probably our only representative in the field, as such, but we have applied physics in the navy ever

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since the new navy was started, and have applied it in a greater variety of ways than in almost any other mechanical way.

The Boston navy yard isn't situated in Boston at all, it is in Charlestown. The same is true of every yard on the coast; take the Portsmouth yard, it is in Kittery, Me., the New York yard is in Brooklyn, the Norfolk yard is not at Norfolk, the Pensacola yard is at some small village about five miles away from Pensacola, and the New Orleans yard is at Algiers, across the river. The reason for this is that the politicians run things to suit themselves, and it has become a custom to name a yard after the nearest large city.

The point, formerly known as Moulton's Point, on which the yard is situated, is at the junction of the Charles and Mystic rivers. Boston very early began the art of ship-building. I think it was in 1631 that the first ship was designed, laid down, and launched here in Boston. It was named the "Blessing of the Bay," which shows the reverential state of mind of the people at that time. At that time pirates infested some parts of the coast, and the Blessing of the Bay was soon refitted as a privateer. Boston, therefore, had the very first vessel of war in these colonies.

Congress very early thought it advisable to have some sort of yard here at Boston to fit out and supply ships. In 1801 the first appropriation was made. Mr. Benjamin Stoddard paid a visit to Boston in 1800, and while here wrote, "Here, or rather at Charlestown, is a very proper situation for a building yard, but the land cannot be obtained for less than $18,000." Immediately after that, and probably as a result of the visit, the State of Massachusetts ceded to the general government thirty-five acres of land, and that, taken with the purchase of several parcels, and land reclaimed from the harbor, has increased the acreage to one hundred and eleven. The big wall that surrounds the yard was built in 1825. The first building still stands in the yard, and is known as No. 5. It was built in 1803, and was intended for the officers and for the caring of stores, and at that time the building was sufficient for the needs. The commandant's residence was built in 1809, and was designed by a very prominent architect of that day; I think it was Mr. Bulfinch, who also designed the state capitol. The row of officers' quarters were begun in 1833, and others in 1836. All these are the oldest buildings in the yard, the others being comparatively new.

Leaving the question of buildings, and going to the question of ships, the navy yard has the record of having laid down and launched fifty ships, some of which in their day have been very famous. The old Chesapeake was fitted out under Captain Lawrence, with a green and untrained crew, and went outside to an engagement with the Shannon, which very naturally captured her. An incident of this sort wouldn't be heard of in this day. The

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captain was forced into the battle by public opinion, without having time to fit out, and history tells the rest. Admiral Farragut's flagship, the Hartford, was built here. The Merrimac was built here, and when the Civil War broke out was burned and sunk, and later was raised by the Confederates, who built a house of iron on her and sent her down to Hampton Roads to destroy our wooden fleet, which she almost succeeded in doing, until the Monitor came along. The fine old frigate Cumberland was built here, and so on down through a long list.

The yard continued to grow from Colonial times up to the Civil War very gradually, during which time 3700 men were employed here. Contrary to public opinion, the old Constitution was not built here; it was built over in Boston at Constitution Wharf, which was named after her. After the war, during which time the yard was very busy, Congress allowed the navy to go to ruin, and the yard became smaller, and practically nothing was going on here, less than 500 men being employed.

But at no time was the yard entirely dead. This yard has always had three industries. The first is the rope-making industry. We make here all the rope that is used in the navy, from the smallest lines to the nine inch hawsers. We import from the Philippines in ships directly to Boston all the hemp that is used in that rope, and it is really a fine grade of rope.

Another industry is that of chain and anchor making. The making of anchors here has practically been abandoned, because of a new modern type of anchor, having a mushroom head, which is now being used in the navy. But the chain-making continues, and we make chains three inches in size.

The boat building is the third industry that hasn't died out. We make the smallest punts, etc., up to the fifty-foot motor launches and picket boats.

The yard was at low ebb during the '70's. From 1876 to 1882, when they began to build a new navy, things were very dull, but after that things picked up a little. When Mr. McKinley was in his first term of office, ex-Governor Long of Massachusetts was Secretary of the Navy, and he was not slow in seeing the advantages of the Charlestown yard; its proximity to the sea, the ease with which it can be defended, its nearness to the labor market, and to the large centre, Boston, the splendid railroad facilities, and shipping facilities, and the fact that it is a very recuperative climate for officers and men who have been in the West Indies. It seems to be a habit of the government to get them down in the West Indies, and forget them, and the result is that they really need a little New England climate to brace them up.

Mr. Long succeeded in sending ships to the yard, and it has

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now gradually worked up, until at the present time 2000, and sometimes 2500 men, when it is active, are employed.

The large dry dock, the larger of the two, which took five years to build and cost $1,125,000, is about 750 feet long and 141 feet wide. It may interest you to know that 100,000 barrels of cement were used in its construction. Some of the foundation rocks measure 10 x 10 x 10 feet. We didn't have any difficulties here as they did in New York, where they found quicksand, and were forced to erect a number of pillars through the sand down to bedrock. It was a tremendous undertaking, and certainly cost $1,500,000 more than this one.

The smaller dock was built from 1817 to 1833. The first ship docked in it was the old Constitution. In that time it was a prominent event, and a large assemblage was present. The commandant took active part in the affair. Nowadays all this is left to other officers.

The yard has had a great many commandants since its institution in 1800, and many of them have been quite distinguished men. The first commandant was Bainbridge, who served three times, having a total period of fifteen years, which would be unheard of in these years. But in those days the commandants were often so long in office that they got the notion that they owned the place. I know of an officer in a station in the West who, when he died willed certain things in the yard to his family. Admiral Sampson has been commandant here. Joshua Dacres was acting commandant for a short time.

A good many people have been interested in the workmen of the yard. Of course, that is a point of political interest to the people, and the demand for work in the yard is very great. But the rules are very strict. Men who are taken on in the yard must first register with the Labor Bureau in the yard, and they are taken on in the order of their registry, with certain exceptions. First preference is given to veterans of the Civil and Spanish Wars, who served at the front. Second preference is given to those who served in the wars, but did not get to the front. Then come those who served twelve years in the army and were honorably discharged. Then after that they take those who have had military service in the yard as mechanics. Then comes the marine of naval corps who have served six years. Then the public at large. But really there is scarcely a handful here, about 95 per cent. of the employees being men who have had no military service whatsoever. It does not shut anybody out. There is very little more of historical interest in the yard. I know of no further incidents that would interest you.

There has been a good deal of talk about a possible sale of the yard. The point brought up was that it would be cheaper for the government to abolish the Portsmouth, Boston, and New

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York yards, and to establish a large station at, say Narragansett Bay. Narragansett Bay has plenty of room and water front; a yard built on modern scientific principles there would be run for little more than the cost of one of the yards now in use. The economy to the government would be very great, but the government couldn't get anything like the real value of the yards. Then comes the still greater point of politics. No member of Congress would give his consent to have anything taken away from this district, and everyone will help the others. The Secretary of the Navy today has laid before Congress a scheme whereby to close down and, if possible, sell a number of navy yards which we do not need at all. But although they are unnecessary, you can't do it. They continue to appropriate money for their upkeep. Almost every coast Congressman has a navy yard or a coaling station in or near his district. Boston has one, Narragansett Bay has one, New York has one, New Orleans has one. There isn't a coast Congressman who hasn't a navy yard within reach, and in order to keep his own safe he must stick with the others in protecting their own interests.

Let me say to you that aboard the Virginia there are more applications of the laws of physics than in any other space of equal size and similar dimensions. The principles of physics are there applied in a more diversified way than in any other space of like dimensions in the world.

I thank you very much for having listened to me so quietly, and hope you will have a pleasant time in visiting the Virginia, the rope walk, the chain shop, etc. I have arranged with Mr. Clark, who is a very fine fellow, who will take you around this afternoon, and show you everything that the yard affords in the matter of interest. I thank you.

Commander E. J. Pollock then spoke on

THE BATTLESHIP VIRGINIA.

It is regretted that there is no later type of ship here than the Virginia which could be inspected by you, but such as she is—and we are proud of her and of all her achievements—she will be open for your inspection this afternoon and officers will be detailed to show small parties throughout the ship.

The old Constitution, the only ship in the American Navy which won every engagement in which she participated, will show you better than I can tell you the difference that has taken place in shipbuilding in the last 125 years. With her length of about 175 feet and displacement of about 1700 tons, and a crew of nearly 500 men, she is in striking contrast to the Virginia, with her displacement nearly ten times as great, length 435 feet, and crew of about 900.

The old Constitution, with her smooth bore broadside, was

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most effective at what is now easy rifle range, a few hundred yards, while the Virginia, with her 12-inch and 8-inch guns, about forty feet long, would begin an engagement at about seven miles. On the last target practice the mean range was 11,300 yards, or well over six miles, and as a result of that practice the Virginia set the pace for all the other ships of the battleship fleet for 12-inch and 8-inch guns, as we now express it, in "hits per gun per minute," and, as it has been said, "it is the shots that hit that count." The Virginia stood No. 2 in individual ship practice, firing at a target 30 feet high by 60 feet long.

Merchant ships in their advertisements generally speak of the gross tonnage of the ship, while men-of-war give their displacement, which, of course, represents the weight of the water displaced. For a merchant ship, the cargo that she will carry is anywhere up to two and three-quarters times her registered tonnage, or up to about one and one-half times her gross tonnage, this tonnage being determined by measurement (so many cubic feet to the ton, with deductions for engine room and living spaces, etc.), according to rules established by law. For instance, the ill-fated Titanic had a gross tonnage of about 45,000 tons, and displacement of about 66,000 tons, or over four times that of the Virginia.

Those of you who saw the caravels representing the originals in which Columbus crossed the Atlantic, or who have read descriptions of the later Mayflower, cannot help but admire and wonder at the courage of those early navigators who started off in such small craft over almost unknown seas, with little knowledge of winds and currents and very inadequate charts and navigation instruments. It has always been a wonder to me how they ever found their way to this country, knowing nothing of the shoals, rocks, etc., on which they might be wrecked and on which a few of them were lost.

The difference between wood and steel construction is so very marked that I must state that frequently when a wooden ship struck anything, not too heavily, the force of the blow would be distributed owing to the resilience of the wood, while an iron or steel ship would be penetrated. If the shock were severe a wooden ship would probably be lost, but in these days of double bottoms and water-tight compartments, with doors that can be closed automatically and simultaneously throughout the ship by turning a lever on the bridge, the damage to a steel ship could generally be confined in one compartment.

A ship of the Virginia class has over 200 of these watertight compartments, from well above the waterline down, while the Florida and Utah, our latest battleships in commission, have nearly 400. These watertight compartments are primarily to

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limit the damage to a man-of-war in action and, of course, are more numerous than they are on merchant ships.

The arrangement for closing the watertight doors simultaneously throughout the ship by turning a lever on the bridge was not installed on the Virginia; consequently, in case of collision, all of these doors are closed by hand. Of course, a large majority of them are kept closed at all times at sea and at all other times except when men are actually at work in them. This refers more especially to the double bottoms, trimming tanks and lower storerooms.

The signal for closing watertight doors consists of a long blast on the siren, which can be heard throughout a great part of the ship; the general alarm gongs, which ring about the upper decks as well as down below; and the solenoids, or whistles, which are installed in the various passages, engine rooms and fire rooms below. The general alarm gongs are for a general call and are installed throughout all the living spaces, so that at night they would awaken everybody by their ringing for several minutes. The siren is used only for collision call and can be heard throughout the greater part of the ship, while the solenoids give the alarm to the men at work down below.

At these alarms, every officer and man of the 900 on board go at once to their stations, closing the doors and hatches farthest from the escape hatch and sees that no one is left closed in as they gradually make their way to the deck. Some are stationed to get up provisions and water for the boats, some to provide other necessary gear for the boats, some to tend the cranes and boat-falls, some to assist the sick on deck, until out of the rush and apparent confusion there results in everybody being assembled at their stations for abandon ship, except those few to keep the fires, pumps and necessary machinery going until the last call for abandoning ship, which we hope never to see.

When at sea, all watertight doors, hatches, etc., are closed daily for exercise to see that they are in efficient working condition, and weekly the entire drill is gone through with. All the hatches and doors, with their rubber gaskets to insure watertightness, are carefully inspected and any occasional deficiency is remedied at once.

Besides this, a detail provides a large collision mat to be placed over the opening in the ship's side, with wire or chain leading under the bottom and fore and aft, to stop the inflow of water. All fire and bilge pumps can be connected in the engine room to pump out any particular compartment which might be flooded. The different compartments are all numbered with reference to four divisions beginning from forward, and by numbers beginning from below, so that any particular compartment can be designated and its location understood at once, while the maga-

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zines have a separate letter in addition to the division letter and deck number.

As a warning of probable fire, there are thermostats in the various storerooms, magazines and coal bunkers, which, when the temperature reaches a certain height, automatically ring a bell and show the compartment number on an annunciator, which is all the time under the eye of a sentry and in the neighborhood of the captain's cabin and the senior officers. These alarms are very sensitive and sometimes go off accidentally. While this occasions a little annoyance, it serves to keep everybody alert, and results in a drill at irregular times.

On going around the ship you will see many fire plugs with hose carefully stowed near them, and when the fire alarm is sounded these hose are coupled up and led out, all the doors in the neighborhood are closed, hatches are battened down, and a helmet with hose connected to one of the two diving pumps, one of which is forward and one aft, is taken to the scene of the fire, so that a man may enter a smoke-filled compartment without danger while wearing this helmet. This hose is long enough to reach from the pump to almost any part of the ship.

To start on another tack and tell you a little of the ship herself: The Virginia is one of the three battleships authorized in 1899, the others being the Nebraska and Georgia. The two others of this type, the Rhode Island and New Jersey, were authorized the next year. The vessel was launched in April, 1904, and commissioned in May, 1906, and has been in continuous active service ever since, being one of the fleet which made the tour around the world. The cost, excluding the armament, certain portions of the armor, etc., was about $3,600,000, of which about $1,200,000 was for the machinery. When the cost of the armor, armament and equipment in all departments, is taken into account, the total cost is close to $10,000,000. The displacement is about 15,000 tons and draft about 25 feet; when fully loaded with coal, provisions, ammunition, etc., she has a displacement of about 16,000 tons and a draft of about 26 feet. Length, 435 feet; beam, 76 feet; height of her truck above the waterline, about 132 feet. The cage masts are each provided with a top for the fire control party, and there, when ready for service, will be found range finders, telephones, voice tubes, etc.

The battery consists of four 12-inch, eight 8-inch, twelve 6-inch and twelve 3-inch guns, two of the 8-inch turrets being superposed on the 12-inch turrets. The arrangement of the various guns you will see when you go aboard. The boats, most of which are now stowed in the boat-shed in the yard, are two 40-foot steamers, one 40-foot motor boat, one 40-foot sailing launch, two 36-foot sailing launches, one of which has a motor, two 30-foot

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cutters, or lighter square-stern boats, two 30-foot whaleboats, used as lifeboats, and two 20-foot dinghies for light service.

The battery and machinery spaces are protected by armor as follows: The protective deck, extending the full length of the ship, is 3 inches thick on the slope and 1 1-2 inches on the flat; along the waterline in wake of machinery and engine spaces is a side belt 8 feet in width, 11 inches thick at its upper edge, maintaining this thickness downward for a distance of 5 feet, from which it tapers to 8 inches thick at its lower edge. From this heavier belt, 192 feet long, there is a lighter belt extending forward 60 feet towards the bow and 32 feet aft towards ths stern, from 9 inches to 6 inches thick. Forward and aft of this belt are two others, gradually decreasing to a uniform thickness of 4 inches to the bow and stern. Above the main belt, for a distance of 245 feet, the ship's sides are protected by uniform thickness of armor 6 inches to the upper deck. This upper and lower casemate side armor is joined to the barbette of the 12-inch turrets by 6 inches athwartship armor, thus forming a central casemate. The conning tower, 9 inches in thickness, is not in place, and is to be replaced by a new type, of the same thickness, but larger and with space for steering wheel, engine, telegraphs, telephones, speaking tubes, etc., and with a small compartment for the chief fire control officer. From this small compartment, where the chief fire control officer is in direct communication with the captain, the fire of the battery is governed.

The turrets are elliptical, electrically controlled, and balanced, and the 12-inch turrets have an arc of fire of 270 degrees, the 8-inch waist turrets an arc of fire of 180 degrees, and the 6-inch guns an arc of fire of about 110 degrees. The armor on the turrets is 12 inches on the slope, which would be towards the enemy, 10 inches on the front and 6 inches at the back. The 8-inch turret armor is practically the same. The secondary battery, consisting of twelve 3-inch guns, is mounted in various parts of the ship. This 3-inch, with the 6-inch battery, constitutes the torpedo defense battery. Besides these, there are four submerged torpedo tubes, two on each side, each tube and its mate on the opposite side being in one torpedo room forward and the other pair aft. There are also a 3-inch field piece and two Colt automatic guns for use with landing parties.

It is regretted that no drill can be carried on with the battery, owing to the work which is in progress on the various guns and to the fire control system being remodelled. Team work at the battery, in target practice or in action, constitutes everything, and, like in other kinds of team work, each individual of a gun's crew must perfect himself at his own station, then the gun's crew must work as a unit, and, if in a turret, both gun crews must do the same work at the same time and both guns be ready to fire to-

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gether. One trainer keeps his sight on the target at all times, and this serves for the four guns in the case of a superposed turret. The pointer at each gun keeps his gun level on the target from the moment the operation of loading is completed until after the gun is fired. This is what is known as "continuous aim" and, as in wing shooting with a shotgun, the gun must be kept on the target until after the projectile leaves the gun. While the firing interval, or the time that elapses from when the key is pressed until the shell leaves the muzzle of the gun, is almost inappreciable, yet it is sufficient to throw the shot off the target if the gun is not kept continuously pointed at it. When the ship is rolling, as she is most of the time, the pointer must necessarily be expert to keep the gun on the target. Each turret crew having become as expert as possible, the firing of all targets together is regulated by the chief fire control officer and the guns fired in salvo at regular intervals of about 45 seconds. As smokeless powder is used and the gases dissipate quickly, if all the guns are not fired practically simultaneously the gases from the guns ahead will obscure the sights of the guns to leeward, so that when the firing key is pressed it is necessary for all the guns on that circuit to be fired within about five seconds. Of course, if the pointer is not on the target, he does not fire; otherwise the shot would be thrown away.

Ten years ago, a firing interval of five minutes between separate shots in one 8-inch turret was considered standard. In these days an average of less than one shot per gun per minute is not satisfactory. Six years ago the target regulations called for firing each gun separately. Starting with the gun loaded, I have seen three shots made, with three hits resulting, from the same gun in 39 seconds, but the range then was much less than the minimum range which would be used now.

At the beginning of an action, ranging shots are fired with the range as given by the range finder. This range may be accurate or not, depending on the qualities of the powder, as well as on the condition of the atmosphere, and the sight-bar range necessary to bring the shot on the target usually differs materially from the range determined with the range finder. At 11,000 to 12,000 yards the time of flight is 15 to 20 seconds. When the shot strikes the water it makes a tremendous splash, 100 or more feet high. Spotters in the tops are equipped with glasses and, by observing the distance of a splash from a target, send the correction to the guns as generally "up or down so many yards," and on the judgment of the spotter the results principally depend, as the target as seen at 12,000 yards range is very small.

In giving the spotters preliminary exercise without expending ammunition, a miniature target such as I have here is used and the splashes represented by these wads of cotton. The target is

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placed at one end of a spotting board painted to resemble the water, while the spotter is about 25 yards away, close to the level of the spotting board, and practices estimating the correction to be applied as the splash is shifted from one point to another. When various ships are to fire one after another, officers are sent to the ship firing to practice spotting, and the experience thus gained materially aids their own practice. The ship during this practice is steaming at 15 knots per hour on a certain course, while the target is towed by another ship at a speed and on a course unknown to the firing ship, but calculated by observers with instruments kept trained on the target, observations being taken at certain intervals of the bearing and distance of the target. These being applied continuously on a plotting board give very close approximation to the course and speed of the enemy. The range may be found to be increasing or decreasing at a regular rate, and this is put on a range clock which shows automatically and continuously the range. After each salvo a correction is made to this range by the spotters and a new range used.

A good spotter, after two shots, should be able to determine the range within 100 yards, and after the next two salvos should be able to keep the shots falling very close to the point of aim. This all presupposes that the pointers only fire when they are exactly on. The danger space for our 12-inch guns on the Virginia, at 11,000 yards, is about 115 feet, so that it is necessary for a shot to hit the target to have that shot strike within that 115 feet beyond the target. When it is considered that the range is over 36,000 feet, it must be seen how accurate the pointers have to be to have the shot strike the target, which is, of course, much smaller than a battleship even when seen end on.

The main engines of the ship are 4-cylinder, triple expansion, inverted, direct-acting, the cylinders consisting of a high pressure, intermediate and two low-pressure cylinders, one low-pressure cylinder being forward of the other two and the other abaft. The boilers consist of 24 of Niclausse type in groups of four in six watertight compartments. Ordinarily, in port four of these boilers are in use to furnish steam for the auxiliaries, which include the dynamos, various pumps, heating circuits, etc. The Virginia's horse-power is about 19,000. The various pumps are mostly steam, except a few small electric pumps for fresh water. Motors are used for a great variety of purposes, such as for training turrets, elevating guns, working the ammunition hoists, rammers, potato peelers, laundry machines, etc. Some of the later battleships are fitted with turbines, but the latest ones have reciprocating engines similar to those on the Virginia, as at the ordinary cruising speed they are much more economical.

The coal capacity of the Virginia is 1900 to 2000 tons and the daily consumption in port about 20 to 25 tons; while cruising at

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10 knots, about 100 tons, while 15 knots would require about 200 tons per day.

The wireless installation permits ready communication in the day-time from two to three hundred miles, and at night from eight hundred to a thousand. This difference is due to the atmospheric conditions. The distance a ship can send depends on the power of her plant, while the distance she can receive depends partly on that, but more particularly on the expertness of the operators; 1700 to 2000 miles can be received at night under ordinary weather conditions, so that when crossing the Atlantic messages can be received from one side or the other every night, and sometimes both sides can be received the same night.

As to the amusements on board ship,—there are baseball and football teams, raceboat crews, rifle team, and when in Guantanamo, swimming matches, as well as field sports; but the principal one, which all the men seem to enjoy most, is the moving picture show. Practically every ship in the fleet has her own apparatus, and three or four ships generally go in together to rent films. Any night in Guantanamo, and frequently at sea, weather permitting, you can see the lights on the screens of ships throughout the fleet. So that life on board ship is made as enjoyable as possible.

While in port, as we are now, half of the ship's company are allowed to go ashore after working hours until the next morning, and while at the yard, on Saturdays, Sundays and holidays, three-quarters go, as many of them have their homes in the vicinity.

It may be of interest to add that most of the men are young, while some have been fifteen to twenty years in the service, but the average age of the enlisted personnel on the fleet of sixteen battleships which made the tour of the world a few years ago was about twenty-two years, and those are the men who helped take that invincible armada over a cruise of about 50,000 miles without a mishap and with the vessels arriving at all the ports on the itinerary on exact schedule time and more efficient on their return than when they started.

Owing to a disappointment in regard to a man to demonstrate the gyroscope compass, Mr. Griswold took his place and spoke very entertainingly as follows:

THE GYROSCOPE COMPASS.

In place of the demonstration of the gyroscope compass, which we are unable to have today, I wish to say a few words. The gyroscope compass was first tried using the sun and stars, but its lack of success in accuracy brought with it an attempt to utilize the pendulum, which used the same principles with less friction. My information is not very authentic, but on the Utah

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they are about to get it installed. It is said that it varies less than 1-10 of a degree. It is very costly to install, costing about $10,000, and weighing 20 tons.

I wish to speak about the application of some physics principles which we find difficulty in getting the boys to study. For instance, the laws of Newton. The natural application of Newton's laws is for the heavenly bodies. But it is a remote application, and not so interesting as some others, so it occurred to me to speak on the kindred subject of the velocity of projectiles. I have on the next drawing an illustration of a conograph, which I will recommend for somebody to imitate. Let me say that these drawings were made by a pupil in my trigonometry class, whose father was the chief engineer who had charge of the work of raising the Maine. I took advantage of that fact, and secured a talk on the subject of the raising of the Maine. He said that the greatest question was as to whether it was an internal or an external explosion. Investigation showed that it was an external explosion; that there was an external explosion which set going two internal explosions, one aft, and one forward. He argued that the first explosion was an external one because the plates were bent back almost as crudely as if it had been done with a crowbar. Some very slow explosive was responsible for it. In his investigation he went into a store and asked for some explosive. He was told that there was no high explosive in town. On asking how he could get some, he was told by the storekeeper that the natives usually make it themselves, by mixing some saltpeter, sulphur and charcoal. It is that kind which is so slow that you can light it yourself and run out of the way before the charge reaches you. It was evident that it was some of this kind of powder that had blown up the battleship. Another thing which seemed to interest him was the electrolysis that took place there This particular specimen was a cartridge belt which happened to be lying on a bench. The salt water was electrolyzed and in the course of time the iron was deposited on the copper. Another interesting thing was that in reviewing the damage done to articles from the stay under water, some were corroded and others were not touched at all. Rubber was found in perfect condition.

Last term I made a visit to the factory of the Colt repeating guns, and also through the Winchester factory in regard to finding the velocity of projectiles. At the Colts Arms I was surprised to find they had no method, but that all their testing was done at the Winchester works for them. On going to the Winchester works I secured this diagram, which I drew from a little suggestion that he sent me.

What I have to say has a bearing on the last meeting's talks. If I remember correctly, Dr. Hayes spoke on the subject of the

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pyrometer. The men who were employed at the factory had been on the pay roll for a long time and were very set in their opinions, while on the other hand, the present president, being a college man, is quite up to date in his methods. In the department in which the steel loses its tempering and is retempered, there was a man who had never used a pyrometer. In an effort to influence him to use one, they tested him, and found that without a pyrometer, although the temperature of the electric furnace was between 1400 and 2000 degrees, he could judge the temperature within 10 degrees. It was the same with the man who tried the pistols. In front of him he had a rack containing 150 pistols, and he fired 12 shots from each at a target. In watching him I noticed that he took a long time before firing. I asked him about this, and he said the reason was that the target was detached from the building, while he was standing on the floor and his armrest was attached to the floor, and the vibration made it difficult for him to shoot accurately. When he was ready, he pulled a string and down came the target, and he fired. The target looked as if it been pierced only once, every shot being so accurate. I think the man was the second best shot in the world. It seems strange that a man should be the best judge of accuracy in a case like this. It is like down at Princeton, where they have a curved ball pitched by a machine, but no catcher can stand up for that kind of a ball, while they will easily handle the same ball pitched by a man.

To get back to the conograph. I won't take your time with the history of it. The pendulum is the principle of it. Some time after the invention of guns, the subject of gravity wasn't known. It is rather interesting to read some of the old documents of that time. The old idea was that a projectile went for some distance before gravity affected it. They agreed that gravity acted upon it but not until after a given distance.

Of course, the instruments were not very accurate, because the later developments like the electrical devices, were not then known. All the modern conographs are based on the breaking of a screen, or something of that sort, and measuring the distance and time required. There are four that are prominent, the Bassel, the Watnicks, the Noble, and the Boulongé.

The Boulongé conograph is shown here. It depends on gravitation, which is more simple than using springs. These are two electro-magnets. These are two staves of exactly the same weight. These electro-magnets have the same strength, and each of these have the same weight and will fall the same distance. When the gun is fired the projectile breaks this wire, and the weights fall. Of course one of the weights will fall before the other, probably only a fraction of a second. Then you calculate the time it took for that stave to fall that distance, and the time for the other weight to fall, and find the difference between the time. Then you

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have the time it took for the projectile to traverse the distance between the two screens. If it is accurate it would register about .003 of a second, which is a good deal less than .0001 of an inch. The distance is carefully timed. The weight will fall about 28 inches a second. So if you revise your figures it will be about .002 of an inch. But there is no need to do that; you can raise these weights farther up, so that they will have a greater distance to fall, but as it is .003 of an inch it is probably as accurate as you want it. That is used for finding the velocity of the projectile outside of the gun.

The Noble conograph is on the same principle—the breaking of two supports in some way, and recording the time. But in this case gravity is not used. Here we have a row of plugs. Each one has a wire coming down from here and passing through a little hinge with a hole in it. When the projectile comes along it cuts the wire, breaking the circuit. In doing so you get a spark here. Here we have a round disk about three feet in diameter, and covered with lampblack. This disk is revolved at about 1100 inches a second. When the spark comes it burns a little bright spot on the lampblack. Each one of these plugs has its set of battery wires, and you will find that you have a line of burned off holes, where the wires have been cut by the projectile. Now the disk is going at a rate of 1100 inches a second. You then measure the distance on the disk that has been traversed by the projectile, and the distance between the spots, and by putting two and two together you can find the distance and rate of speed of the projectile. Unlike the other instrument, there can be used as many as 18 screens, which makes it easier to verify the results.

In connection with this another instrument to measure the pressure is usually used. This is a little steel anvil, and this is a disk of copper. When the charge is fired pressure from it forces the plunger against the copper, thus deforming it. The amount of deformation is noted, and the results kept and tabulated. It seems that there is still some pressure on the projectile when it leaves the gun. The only way of removing this so as to take advantage of it is to lengthen the gun a little. But the length is so small that it doesn't amount to anything.

Lunch was then served in the hall outside the armory.

AFTERNOON SESSION.

The afternoon was divided into two parts: the inspection of the Virginia, and the inspection of the various things of interest about the yard.

On the Virginia Commander Pollock acted as our host, and furnished guides for groups of ten. The ship was gone over

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thoroughly, and the parts visited included engine and boiler rooms, dynamo plant, refrigerating and evaporating plants, torpedo rooms, turrets, men's quarters and shower baths.

Inspector Clark took the party in hand for the tour of the yard. In this the chain shop, rope walk (both fibre and wire), boat shop (where all kinds, from dingies to steam cutters, are made), the two dry docks, one containing the Des Moines and the other Torpedo boat destroyer No. 4, the Constitution, and the wireless station.

Every one present thoroughly enjoyed and appreciated this exceptional opportunity to see the yard and battleship under such favorable conditions, and a unanimous and hearty vote of thanks was extended to those whose kindness and efforts made the event possible.

The Treasurer wishes the two following notices to be noted:

First, The Treasurer has been obliged, on account of stress of work and family difficulties, to adopt the plan of many of the educational associations, that no receipts will be sent where personal checks are received unless requested to do so by members. Receipts are sent whenever cash or money order is received.

Second, The Treasurer requests members to pay all dues at once in order that he may not be obliged to hold bills unpaid during the summer, as he did last year, when the dues for over eighty had to be held until fall.

Respectfully submitted,

ALFRED M. BUTLER, Secretary.

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REPORT OF THE MEETING

OF THE

Eastern Association

of Physics Teachers

at the Brookline High School

Saturday, November 23, 1912

MORNING SESSION.

Saturday, November 23, 1912, at the Brookline High School.

9.30 A. M.

Meeting of Executive Committee.

10.00 A. M.

Business Meeting.

Reports of Standing Committees:—

On New Apparatus. John C. Packard, Chairman.

On Magazine Literature. G. G. Bulfinch, Chairman.

On Current Events in Physics.—H. F. Hadlock, Chairman.

On New Books. Clarence M. Hall, Chairman.

Election of New Members.

11.00 A. M.

Distribution of Commercial Electrical Current. John C. Packard, Brookline High School.

12.00 M.

New Methods of Treating Some Old Mechanical Problems. Professor Harvey N. Davis, Harvard University.

1.00 P. M.

Lunch.

AFTERNOON SESSION.

2.00 P. M.

Wireless Telegraphy: a Talk on the Present State and Future Prospects of the Art. Reginald A. Fessenden, Director of the Brant Rock Wireless Station.

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MORNING SESSION.

In the absence of President Griswold, who was unable to be present because of a sudden attack of appendicitis and subsequent operation, the meeting was called to order by Vice-President Cowan.

The first business was the

REPORT OF THE NEW APPARATUS COMMITTEE,
John C. Packard, *Chairman.*

Mr. Le Sourd showed a device picked up at Seth Fuller's on Bedford Street, Boston, to be used by beginners in telegraphy to take the place of a key, in learning the Morse code. This consisted of a punched tape which by a series of wheels was passed between two contact points. When the holes passed, the circuit was completed and the sounder acted. Price, 75 cents.

He also showed a mounted ajax motor with two extra binding posts set in the base for making connections with armature independently of the field, the purpose of this being to bring about the following:—

I. With current passing through armature only, test the polarity with small compass and trace the current.

II. With current passing through field only, test polarity and trace current.

III. Connect field and armature in series and draw diagram showing polarity of armature, polarity of field and direction of rotation.

IV. Connect so as to reverse direction of rotation of the series motor.

V. Connect as shunt motor with variable resistance in connection with field, showing variation in speed and drawing diagrams of connections.

The use of the Hoyt Instruments, at $7.00 each, 15 or 20 ampere scale ammeter and 3 volt scale voltmeter, as student apparatus, was shown to be of advantage in studying cell arrangements as follows:

I. Test E. M. F. of each cell separately, open circuit.

II. Find current of each cell separately, short circuited, for an instant only.

III. With two cells in series:—

(*a*) E. M. F. on open circuit.

(*b*) Current and potential difference on short circuit.

(*c*) Current and potential difference with 2 ohm coil.

IV. With two cells in parallel:—

Repeat III, (*a*), (*b*), (*c*).

Questions:—

1. How does connecting cells in series affect the E. M. F.?
2. How does connecting cells in parallel affect the E. M. F.?

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3. Why should III (*b*) show a larger current than III (*c*), but a smaller potential difference?

4. Test Ohm's Law in III (*c*).

5. Find the power (watts) in IV (*c*).

A series of photographs of commercial uses of the electromagnet made by the Browning Engineering Company, of Cleveland, Ohio, were shown.

Mr. Packard then showed a variety of pieces of apparatus and their uses as follows:—

The ordinary household round dial spring balance, at $1.35. By placing triangular supports on centre of balance top and on another support and resting meter or other marked stick on these, a weight may be placed on the stick at any point between the supports and the relation between force applied and resistance shown, bringing out the laws of the lever. If desired, a balance may be at each support.

A new form of Chatillon balance, large size, flat back, similar to the old 32 lb. form, but graduated on one side to read 500 g. in 10 g. divisions, and on the other side 18 oz. in ¼ oz. divisions, and horizontal zero correction on the scale. Price, $1.00.

An arrangement for studying parallel forces. This consists of the usual tall retort stand with two combined vertical horizontal clamps. Into the lower one is fastened a 2-inch brass pivot turned to ⅜ in. diameter on one half and ⅛ in. diameter on the other. The larger half is fastened horizontally to upright clamp, and the other may be passed through holes at the 10, 50 or 90 cm. marks of a meter stick. A brass rod is fastened into the upper clamp parallel with the meter stick, and a spring balance suspended from it at any point. With such an arrangement, the principle of moments may be studied easily.

A right angled wooden wedge about 12 ins. long, 4 ins. high and 6 ins. wide, for the study of the inclined plane.

A maple cylinder bought for five cents at the J. L. Hammett Company. As it comes it is about 4 ins. long, 2 ins. in diameter. If cut to 2½ ins. long and coated with spar varnish it furnishes an excellent waterproof floating cylinder. By having other ones of less length, the question as to when a cylinder turns over on its side may be studied.

A pony brake for testing student horsepower. This consists of a mounted wheel of about 12 ins. diameter and axle of 3 ins. diameter, with a board clamped with thumb screws to the latter. The tension may be varied by the thumb screws. The narrow board extends 18 ins. from the centre of the axle, and to its end is hooked an upright spring balance, on which the pull of the end of the board is recorded. By counting the number of revolutions of the wheel in a

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minute, and noting the pull on the balance, the horsepower of a pupil may be calculated.

The glass front and back combined pressure and vacuum gauge. Knott, 41-70.

A student cell for the study of galvanic action, consisting of the ordinary 250 c.c. wide mouth bottle, into which fits a piece of hard rubber ½ in. thick, cut in the form of a cross so as just to fit into the bottle and stay in place; on either side are placed a piece of zinc and a piece of copper. Wires are attached by means of Dennison clips to which wires have been soldered.

Apparatus for the electrolysis of water. This consists of a block of hard rubber 4 x 2 x ½ ins., through the flat side of which 2 holes ¾ in. in diameter are bored near each end. Through the ends and coming into these holes at right angles are bored holes large enough to take a small one-holed stopper. Platinum electrodes sealed in glass tubing are thrust into these last and the open end of the sealed glass tube, with protruding wire, are covered with a rubber tube about 12 ins. long. If now the block with the platinum electrodes inserted is placed flat in a dish of acidulated water, bottles or test tubes may be inverted over the holes and the gases collected. Knott will furnish this apparatus on request.

The General Electric combined snap switch and fuse box, No. 104947, 110 volt, 6 ampere. This allows for the insertion of a pilot light.

A laboratory circuit breaker similar to the General Electric, No. 75337. This is made by the Westinghouse Company for about $4.00.

A lamp wattmeter. General Electric Company, No. 64635.

An automobile ammeter and voltmeter, to be secured for $3.50 each at Pettingill Andrews, Atlantic Avenue and Pearl Street, Boston. If the copper back is removed and mounted with glass-covered hole in back, the interior construction of ammeters and voltmeters can be shown.

The modified St. Louis Motor of L. E. Knott, Nos. 97-100.

The Carlisle & Finch Company, Cincinnati, Ohio, No. 8 dynamo run by a water motor. An excellent piece of apparatus for use in small high schools where there is not electricity but where water pressure is available. It gives about 4 volts. If this is connected to a set of 4.5 volt lamps connected in parallel, with voltmeter and ammeter on the line to show variations in current and potential difference, many instructive experiments may be shown. Among these may be mentioned the increased current as more lights are added, with accompanying drop in illumination, potential difference and slowing up of dynamo. Throwing off all the lamps causes the dynamo to run away with accompanying increase in E. M. F.

A dissectable transformer. Knott, Nos. 95-30.

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This was followed by the report of the

COMMITTEE ON MAGAZINE LITERATURE,
G. G. Bulfinch, *Chairman.*

Cassier's. July, 1912. "Modern Testing Machines (Shear or Torsion Testing)."

August, 1912. "Eliminating the Dangers of the Deep." (Modern safety devices on board ship.) "Efficiency in Water Filtration."

October, 1912. "Speed Limitations of Air Travel." "Oxy-Acetylene Welding."

Century. September, 1912. "The Story of the Spirals." (The nebulæ investigated by means of the spectroscope), by Dr. E. A. Fath.

Electrical World. July 6. 1912. "Aluminum Conductors for Overhead Transmission Lines."

August 10, 1912. "Study of the Light from an Electric Arc."

August 24, 1912. "Use of Naked Aluminum Wire in Electro-Magnets."

September 14, 1912. "Space Saving Galvanometer." "Cooper Hewitt Diffusing Lamp."

September 28, 1912. "Regulations of the London Wireless Conference."

October 5, 1912. "Quality in Illumination." "Chicago's Latest Generator Station."

November 2, 1912. "Relation of Horsepower to Kilowatt."

Harper's Monthly. June, 1912. "Some Unsolved Problems in Science," by Robert Duncan. "The Secret of the Big Trees" (Cycles of Climate), by Huntington.

August, 1912. "The Motion of the Fixed Stars" (Stellar physics).

September, 1912. "Sun Storms," by E. Walter Maunder, F. R. A. S.

Popular Electricity. September, 1912. "Some Secrets of Electrical Stagecraft," Part V, by T. J. Newlin. "Miniature Lamp Letter Sign."

October, 1912. "Rubber's Secret Conquered," by E. Leslie Gilliams. "Some Secrets of Electrical Stagecraft," Part VI, by T. J. Newlin. "Electric Bell Circuits and Their Installation," by C. V. Davis.

November, 1912. "Edison as a Manufacturer," by H. Bedford Jones. "How to Comply with the New Wireless Law," by Phillip E. Edelman. "The Magnet," by George Frederic Stratton.

Popular Mechanics. July, 1912. "The Wonders of Light," V, Vision," by J. Gordon Ogden, Ph. D. "Great Discoveries Due to Happy Accidents," by G. E. Chamberlain.

August, 1912. "The Seven Wonders of the Modern World." I, The Telephone, Alex. Graham Bell. II, Wireless, F. Minturn Sammis. III, The Aeroplane, A. F. Zahm, M. E., Ph. D. IV, The X-Ray, Robert W. Wood. V, Antiseptics and Antitoxins, E. E. Hyde, M. D. VI, Spectrum Analysis, David Todd, A. M., Ph. D. VII,

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Radium, Herbert N. McCoye, B. S. "The Wonders of Light." VI, "The Illusions of the Eye," by J. Gordon Ogden, Ph. D.

September, 1912. "The Wonders of Light," VII, "The Magic of the Rainbow," by J. Gordon Ogden, Ph. D.

October, 1912. "The Menace to the Skyscraper," by J. C. Miller. "Ocean Ships to Hear the Presence of Icebergs." "The Wonders of Light," VIII, "What Eye Hath Not Seen," by J. Gordon Ogden, Ph. D.

November, 1912. "The Wonders of Light," IX, "The Rise of Photography," by J. Gordon Ogden, Ph. D.

Popular Science Monthly. August, 1912. "Cold Storage Problems," by Dr. P. G. Heinemann.

School Science and Mathematics. October, 1912. "A Simple Apparatus for Determining the Acceleration of a Freely Falling Body," by W. M. Parker. "Learning from Experience," by J. F. Woodhull, Ph. D. (Columbia University).

November, 1912. "An Experiment in Organizing a Course in General Science," by E. D. Huntington.

Scientific American. June 8, 1912. "The Great Tower Telescope of the Mt. Wilson Solar Observatory" (world's largest reflector), by Dr. E. A. Fath.

June 29, 1912. "New Ideas about Lightning," by C. F. Talman. "The New Navy Gyroscopic Compass."

July 13, 1912. "The Business Side of German Science," VII, "Making Money with the Aid of Technically Trained Men," by W. Kaempffut. (Continued July 20.) "The Bacterial Purification of Water and Sewage," by E. B. Phelps (M. I. T.). "Sewage and the Farmer," by Prof. W. T. Sedgwick (M. I. T.).

August 17, 1912. "Sulphur at Home and Abroad—A Contrast between American and Sicilian Methods," by H. C. Plummer.

October 5, 1912. "A Seventy-five Hundred Horsepower Pelton Waterwheel."

October 12, 1912. "Labor-saving Devices for the Home," by H. H. Gordon. (U. S. Patent Office.) "Labor-saving Duplicating Machines for the Office; A Review of Methods Old and New," by H. S. McCormack.

Scientific American Supplement. June 1, 1912. "The Influence of Ozone in Ventilation," by L. Hill and M. Flack.

June 22, 1912. "Experimental Evidence Concerning the Structure of the Atom," by A. W. Hull. "A Theory of the Welding of Steel and Its Practical Application," by Max Berman.

July 6, 1912. "Temperature and the Properties of Matter" (from absolute zero to 6000°C.), by Prof. E. F. Northrup.

July 20, 1912. "Origin of the Milky Way," by Prof. A. W. Bickerton.

July 27, 1912. "Electricity as a Factor in Civilization," by Dr. J. Siegel.

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August 3, 1912. "Making the Blind Hear Light—Fournier d' Albe's Optophone." "Forcing Plants by Means of Radium," by Dr. A. Gradenvitz.

August 17, 1912. "Welding by Electricity."

August 24, 1912. "A Review of the Physics of Light," by Silvanus P. Thompson. (Continued August 31 and September 7.) "The Light Quantity Hypothesis," by Prof. D. F. Comstock (M. I. T.).

August 31, 1912. "The Earth's Atmosphere," by Prof. A. W. Ewell. The Uses of Acetylene," by Prof. V. B. Lewes.

September 14, 1912. "Sir William Herschel," by Prof. G. H. Darwin.

October 26, 1912. "Weighing the Atom—Sir J. J. Thomson's New Method of Chemical Analysis," by F. W. Aston.

Technical World. August, 1912. "Making Weights and Measures Fair," by Richard Benton.

September, 1912. "Making Artificial Daylight," by Robert Franklin.

October, 1912. "Marconi's Plans for the World," by Ivan Narodny.

November, 1912. "Science Makes Artificial Rubber," by R. G. Sanford.

World's Work. November, 1912. "A Practical Cyclone Detector."

This was followed by the report of the

COMMITTEE ON CURRENT EVENTS IN PHYSICS.
H. F. Hadlock, *Chairman.*

In making holes in rubber corks, it is found that by pouring a little ammonia water on the rubber and the boring instrument, the annoyance of "tapering holes" and "running to the side" is removed and the work is accomplished with much more ease.

The United Railways of Cuba have ordered an electric storage battery train for use on a line running about one hundred miles out from Havana. The train is equipped with the multiple unit control; in other words, the separate motors on the cars are operated by a single controller. Each car is equipped with 216 cells of Edison battery, furnishing 200 volts to the motor. The cars are mounted on double trucks and each car carries four motors. Each car accommodates forty-two passengers. In a recent test it was found that the cost of running the train was about $2.00 for a trip of fifty miles. The train in this test consisted of three cars.

Extensive nitrate works in Norway are being operated by power furnished by the lakes and rivers whose lofty elevation and rapid fall provide ideal conditions for the cheap production of hydro-electric power. In the Vemork power house there are ten units, each consisting of two 7500 horsepower Pelton water wheels installed side by side in a common shaft, upon which are mounted also double generators. The working voltage furnished to the nitrate works is 10,000.

Electrical power will be used almost exclusively for operating the

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Panama Canal. The hydro-electric station will be situated near the north wall of Gatun spillway and will have a capacity of 6,000 kilowatts. The average hydraulic head throughout the year will be about 75 feet.

The Lewis automatic aeroplane gun was recently given a successful trial by the U. S. Army Aviation School, Maryland. It is a queer looking object, somewhat resembling an inverted telescope with a disc-like attachment at one end. The gun magazine holds 50 cartridges, and in a test with the aeroplane going at a mile a minute and 600 feet above ground, every shot hit the target. The gun can be fired at the rate of 750 shots per minute. It takes but 4 seconds to discharge a magazine of 50 shots and 2 seconds to reload. This rapid firing might heat the barrel but for an ingenious arrangement whereby a blast of air is automatically produced. It weighs only 25 lbs. and has absolutely no flame or recoil. For all this there are but 47 parts, making the whole very simple and very suitably adapted for aeroplane use.

Government Wireless Around the World.

Our government has always been foremost in the use of wireless telegraphy, and again it has taken the lead. A system will soon be in operation which will outcompass anything other nations have ever dreamed of, and will make the U. S. proprietor of a system of communication covering more than half the globe.

The first of the big stations comprising the system has been erected at Arlington, Va. It consists of three huge steel towers much resembling the Eiffel structure at Paris, which is also a wireless station. The tallest is 650 feet high and 150 feet square at the base, by far the largest tower ever constructed for the purpose. The other two are 450 feet. The gigantic network of wires are spread among these three towers.

The design adopted at the Arlington station will be followed in the other seven stations. Each station is to have a sending radius of 3000 miles, and in atmospheric conditions are just right this radius could be increased to 5000 miles.

Synthetic Rubber.

The discovery of synthetic rubber was purely accidental. The rubber can be made for as low as 20 cents per pound, although as yet it has not advanced beyond the laboratory stage. A bottle of isoprene was sealed up with a wire of sodium and left for future inspection. That was in July, 1910. Last August it was accidentally discovered that the contents of the tube had become viscid and contained a proporiton of a remarkably good variety of rubber. It was again set aside and in September the contents had changed entirely to a mass of amber colored rubber.

Isoprene, the basis of synthetic rubber, is an oily, volatile hydrocarbon. It has been known for about 50 years. It is presenting a

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two-fold problem, the first being how to derive it from abundant raw materials and secondly, to convert it cheaply into rubber through cheap agents. The new process, which involves isoprene is far ahead of other processes inasmuch as the action is merely quantitative and is not seriously affected by the presence of impurities. Temperature does not have to be taken into consideration either.

The discovery of synthetic rubber is not entirely due to one man. Professor Fernbach worked six years to produce fusel oil from which isoprene is cheaply made. It was Dr. Matthews who put the sodium wire in the isoprene and later discovered the rubber. However, the idea was worked out by an association of the most distinguished English scientists working together with Prof. W. H. Pekin as leader of the movement.

Inventive genius has now made it possible to look into nearly all the hollow organs of the body, during life, and to examine same. People frequently swallow things which lodge in esophagus or in the bronchial tubes. The bronchoscope is a tube with a handle and a mirror by means of which surgeons can look down the bronchial tubes and locate such foreign bodies, and by means of other appliances they may be removed. Another attachment on this instrument, by means of cleverly arranged mirrors and a small electric bulb, allows the surgeons to have a complete view of the stomach. By the use of this ingenious instrument much suffering has been avoided.

Ocean Ships to Hear the Presence of Icebergs.

Getting his idea from the bat, which has a facility of avoiding objects even in the blackest degree of darkness, Sir Hiram Maxim proposes to equip ships with a mechanical apparatus which will perform the same function. Maxim says that when a bat flies about in total darkness the beat of its wings sends out air waves which strike against objects and are reflected back and are received by sensitive organs which form a part of the bat's face. Thus by this "sixth sense" the bat is enabled to judge the distance to any object by the lapse of time between the sending and receiving of these very faint waves.

The apparatus which Maxim has devised for ships comprises a device for sending out the necessary air waves; another for receiving them and making them known by ringing a bell; a third for recording the amplitude of the waves, which simply makes a written diagram of the atmospheric disturbances. The first consists of a siren, using high-pressure steam, and producing powerful air waves having a frequency of 14 or 15 vibrations per second, which is too low to be heard by the human ear but being of such great power they can travel great distances, and upon striking any object they will be reflected the same as sound waves, although the echo will be as inaudible as the primary vibrations. The second device or re-

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celver consists of delicate membranes and diaphragms so arranged as to close electrical circuits which ring the bells. Feeble waves or those coming from afar would have but a slight effect on the diaphragm and thus would close only the first electrical contact and thereby ring a small bell. Larger and nearer obstructions would close a second contact and ring a larger bell, and so on, thus giving warning of danger.

This was followed by the

REPORT OF THE COMMITTEE ON NEW BOOKS,
C. M. Hall, *Chairman.*

Mr. R. C. Bean read a

REVIEW OF HAWKINS' "APPLIED PHYSICS."

A discussion a few days ago among a group of Physics teachers as to the best text-book to use in a high school Physics course is typical of the feeling of teachers in general. We are all in search of a book which will embody the fundamental principles, which will be alive and practical and contain enough mathematics to meet the college requirements. The book which I have been asked to review does not by any means satisfy these demands, but it is at least different enough from the books which we know so well as to arouse our interest.

Hawkins' Applied Physics is a small book of only 199 pages, published by Longmans, Green and Company. The type is clean cut and the diagrams are clear. One notable feature is the entire lack of sub-headings to which we are so accustomed. For example, in the chapter on Mechanics of Fluids there are 22 pages of text not broken up except by diagrams. This is in line with the author's attempt to get a text-book which is alive by excluding a large mass of mathematics generally found in such texts. He believes that the pupil should be held responsible for all the text. Applications of principles are not exhausted, but these are left out purposely so that each teacher may fill in with such applications as fit his or her special environment. Illustrative experiments are rarely inserted. This, too, is left to the teacher. If the teacher performs experiments the author thinks such descriptions superfluous, and if the teacher does not, the descriptions are of little value.

An introduction of two pages on Matter and Energy leads to Chapter I, on Machines, where work, efficiency of machines, principle of machines and mechanical advantage confront you on the first three pages. Except for its abbreviated form the text is not different from that ordinarily found. The Micrometer, Caliper and Pony Brake are introduced in addition.

A chapter on Mechanics of Fluids is very well done but here, as elsewhere, the molecular theory is freely used in explanations, and in some cases it seems to me far too much is expected of the pupil

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in this. A very brief explanation of capillary action and surface tension seems to show what it ought to show without mathematics or tedious definitions.

A brief chapter of six pages on Strength of Materials reminds us of some of the older books.

In the chapter on Light there are a series of cuts of the optical disc showing reflection, refraction, etc. This is in line with practicality as the optical disk is used by nearly all teachers.

In Heat not only is the Caloric used but also the British Thermal Unit. An illustration of the method of treatment might be taken from the text at this point. Freezing is a heat-producing process. When a pound of Lake Erie water freezes, it gives up heat to the air to keep the city warm. The same pound of ice placed in your refrigerator must take in 144 B. T. U. in order to melt and it takes this from the surrounding substances.

A whole chapter is devoted to engines. In addition to the ordinary steam engine, the turbine, the gas engine and a simple hot air engine are described. Also the steam-indicator is taken up in detail.

The treatment of Magnetism and Electricity are the widest departure from the ordinary text. The historical method has been discarded. Immediately after the magnet the dynamo is introduced. Cells are not brought in until electro-magnets and their applications have been treated. Static electricity is placed near the end as an introduction to x-rays and wireless telegraphy.

On the whole the book may not suit our individual requirements, but there are many features which seem to be a step in the right direction.

Mr. C. M. Hall read a

REVIEW OF "ESSENTIALS OF PHYSICS."

By George A. Hill. Published by Ginn and Company, Boston.

The book is well named, for it is a set of questions and answers, with all padding left out.

Quoting from the preface: "The method may be described in a few words. A definite question is asked. If it is of such a nature that the student cannot be expected to answer it correctly, it is answered in the text. This is followed by questions and problems for the student. Throughout the book, when a general principle has been explained, the student is called upon to show its usefulness by solving numerical exercises.

"This method is employed by every teacher in the classroom, and is the only method by which he can be sure that the intellect of his pupil is taking an active part in the work. Of course it is the only method possible for written tests and examination papers.

"The importance of numerical problems cannot be expressed in too strong terms. Pages may be written about a principle in physics, describing how it was discovered, explaining and illustrating what it

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means, stating under what conditions it holds true, etc., but all this, however well expressed, makes little impression on the mind of the average student. On the other hand, the solving of problems that demand for their solution the application of a physical principle so fixes the principle in the student's mind that it sticks there."

The book suggests strongly a catechism and it is interesting in this connection to note that a book on physics similarly arranged was published in New York in 1860, written by a Mr. Parker, once principal of the Johnson Grammar School, Boston.

This old book I have here and some of the members may be interested to glance through it.

I assume that the "Elements of Physics" is to be used in combination with lectures and individual laboratory work. The teacher will find he has much explaining to do and he will be obliged to enliven the subject and make it interesting. Hence it may be somewhat difficult for the new teacher to use this book just as it stands, a set of questions and answers. The book gives comparatively little space to explanation and this will have to be supplied by the teacher. The questions are, however, most excellent, although perhaps too many are mere "memory" tests and require no reasoning on the part of the pupil. For example, p. 11, No. 11, "What laws relating to the action of gravity on a liquid at rest can be verified by experiment?" *Answer:* "The pressure within the liquid increases directly as the depth. At every point in a horizontal plane the pressure exerted by a liquid has the same value."

The general idea of the book is good, I think, since it gives a pupil the wording of a question the teacher may ask him and furnishes him the accurate form of answer well expressed. Pupils are often unable to put their thought into clear statements and these model answers would tend to cure this trouble. It would seem that this scheme would make for definiteness in recitation work. The thought occurs to one, however, "Suppose the teacher asks a question not in the book or worded differently from the answered question?" Will the pupil have reasoned out his principle so well that he can answer correctly, in good English? If he has been depending upon the book too much, he will probably fail, in putting his ideas into words.

If one were to adopt this book he would be able to do away with a separate problem book as there are plenty of excellent exercises in it.

The character of the questions may be inferred from the following questions:

P. 21, No. 13. "What weight of zinc ($S = 7$), and of copper ($S = 9$), must be taken to form 100 g. of an alloy of specific gravity S, assuming no change of volume to occur?

P. 24, No. 11. "Describe Torricelli's experiment. What does it prove?" *Answer* to part two: "It proves that the pressure of the

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atmosphere on the earth is equal to that which would be exerted by an ocean of mercury 76 cm. high."

P. 162, No. 16. "How is latent heat of vaporization explained by the mechanical theory?" *Answer:* Heat of vaporization is expended partly in doing external work and partly in doing internal work. The external work consists in pushing the atmosphere out of the way so that 1c.c. of water may expand to about 1650 c.c. of steam. The internal work consists in separating the molecules from one another and possibly in giving a motion of rotation to the molecules, and a motion of vibration to the atoms of which they consist. For boiling water, the external work consists of about 40 cals. per gram and the internal work amounts to 537-40, or about 497 cals. per gram. All this energy, when steam condenses, reappears in the form of sensible heat and raises the temperature of surrounding bodies."

On p. 186, No. 5, the author must have had the prospective college boy in mind, as he asks the question, "How do you explain the coloring of a meerschaum pipe?"

One notes with approval on page 258, the following: "A generator does not produce electricity, but electric energy; and it produces this at the expense of some other form of energy. It simply transforms some other kind of energy into electric energy. To say that the generator manufactures electricity is as gross an error as to say that a pump manufactures water."

A good answer is given to the question, "What is the zero of potential difference?", as follows: "In expressing heights above the surface of the earth we take the sea level as the zero of reckoning. In expressing differences of potential we assume that the earth has the potential zero; whence it follows that every body electrically connected to the earth will also have the potential zero.

"This is analagous to the method of measuring temperatures. A Centigrade thermometer does not measure the absolute temperature of a body, but the difference between its temperature and that of melting ice, which we call zero degrees. In like manner instruments for measuring electric potentials measure simply the difference between the potential of a body and that of the earth assumed zero."

"Potentials lower than that of earth are marked-like temperatures below the Centigrade zero."

An apparent error appears on p. 265, where the Weston ammeter is pictured and described as a magnetic needle type, instead of moving coil. Aslo on p. 281, No. 11, arc lamps are said to be "connected for the circuits in series," whereas many are nowadays run in parallel on 110 volt circuits. The explanation of the action of mercury in stopping local action in voltaic cells is insufficient. As a whole, the questions are clear and most excellent, showing the result of classroom experience on the part of the author. There is a handy refer-

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ence set of tables in the book and the work of the printer has been well done. The book represents the swing of the pendulum from the extreme of much padding for purposes of arousing interest, to the other side, the essentials in cut and dried form ready for use. It is a good book with which to drill pupils on the essentials of physics for college entrance examinations.

Mr. Edward Sturtevant then read a

REVIEW OF "ELEMENTS OF PHYSICS."

By Edwin H. Hall. Henry Holt and Company.

This carefully prepared text-book is intended for use in the later years of school or the first year of college and covers in a well systematized plan the subjects of Mechanics, Heat, Sound, Light, Magnetism and Electricity, in the order given. Although necessarily brief, all the most important laws and principles are clearly stated, and the scholar is not over burdened with unimportant matter, so often found. Professor Hall's great experience has enabled him to so logically plan the book that each topic follows in a progressive way upon the last, until the student is surprised to find how easily he has acquired a real knowledge of physics. The text is not interrupted with instructions for laboratory experiments, these being placed at the end where one finds a collection of fifty for the student's laboratory course.

As stated in the preface, the book is the natural successor of Hall and Bergen's Text-book of Physics, although some of the simpler exercises have been omitted, replaced, or merged into others. Certain new matter appears, including a chapter on Molecular Attractions, and treatment of heat engines, optics, and the application of electro-magnetism is included.

Questions and problems are dispersed throughout the book, and under a separate cover are published suggestions for teachers, answers to the questions and problems, and lists of apparatus required.

No teacher in following Hall's "Elements of Physics" could fail to give a most interesting and valuable course.

By unanimous vote the following application for associate membership, recommended by the executive committee, was approved:

Louise S. McDowell, Wellesley College.

The secretary then spoke of the illness of Mr. Griswold, whom he reported as having had a very successful operation and rapid recovery, with expectation of returning soon to Groton School. Mr. Griswold sent his best wishes to the members of the Association and keen regrets that he could not be present. It was voted that flowers be sent to Mr. Griswold in token of appreciation.

Mr. Miller then spoke of the new laboratory experiment list for Harvard requirements and brought up the advisability of requesting additions to this list in the way of an experiment on the efficiency

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of some machine. This was referred to the committee on College Entrance Requirements.

Mr. Packard then spoke on

"Distribution of the Commercial Electric Current in the Brookline High School.

There are three sources of electricity in the laboratory, as follows: a 110-220 volt D. C. from the municipal plant in the Manual Training High School, a 117 volt A. C. from the street mains, and a 0-25 volt D. C. from a motor dynamo set in the laboratory, run by the 110 volt D. C. from the municipal plant. The 110-220 volt D. C. and the 117 A. C. lines enter the preparation room of the Physics Laboratory, where they feed two of three switchboards. Branch lines lead from each of these switchboards to the various parts of the laboratories where the current is desired. The motor dynamo is run by the 110 volt D. C. and feeds the 25 volt D. C. switchboard. The motor is a 3 H. P. one and the dynamo will give 60 amperes at 25 volts under normal conditions. The field rheostat controls the speed of the motor, which can be varied between 800 and 1750 revolutions per minute. The switchboards in the lecture room and laboratories have three switches for 117 volt A C., 110 volt D. C. and 25 volt D. C., respectively. The switch in the basement is fused for 60 amperes. At the laboratory main switchboard it is fused for 55 amperes, and in the lecture room 50 amperes. As there is a pilot light between every switch and the next higher fuse, it is a simple thing to trace any burnt-out fuse.

Professor Harvey N. Davis of Harvard University then spoke on

"New Methods of Treating Some Old Mechanical Problems."

A Simple Method of Teaching Newton's Second Law.

Of the various topics in mechanics which are taught in high school courses in Physics, Newton's second law, which enables us to compute the acceleration produced by a constant force, is undoubtedly one of the hardest. Indeed there are many teachers who believe that it is so difficult as not to be worth the time necessary to teach it properly, and have proposed to omit it altogether. The question thus raised is one which I do not propose to consider this morning. I shall assume, for the time being, that we have decided to do all we can with Newton's second law in our class rooms, and I shall ask you to consider merely how we can handle it in the simplest, clearest, and most efficient manner.

The classical treatment based on the equation

$$F = ma,$$

with its insistence on the fundamental importance of poundals and dynes, is familiar to you all. In contrast with it, I want to outline a treatment that I have used for two or three years in both ele-

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mentary and advanced college classes, which will, I hope, appeal to you as suitable for high school classes also. If, in presenting my case, I seem to phrase myself too positively or dogmatically, in my enthusiasm, I hope that you will forgive me, and will understand that my purpose is simply to start such a discussion as will help us all in our future teaching. Please do your share by attacking me vigorously at every opportunity.

It would be presumptuous for me to claim any originality for the treatment which I shall suggest. Almost every novel feature of it I have absorbed from my friend and colleague, Prof. E. V. Huntington, who was the first of our group of teachers at Harvard to see clearly that the previously discredited "engineer's treatment" of elementary mechanics can be made just as precise and rigorous in its logic as the older treatment of the physicists, and that it is in many ways easier to understand and to use. I remember that when he first began to talk it to me I thoroughly despised it, and used to argue with him about it by the hour. Finally I reluctantly tried it in one of my classes and was surprised to see how well it worked. And since that time I have become more and more firmly convinced of its excellence.

One of my experiences with it is especially significant. A year or two ago I taught a course in elementary mechanics at Radcliffe College to a class, some of whom were taking their first course in calculus at the same time. It happened that they reached the admirable chapter on mechanics in Osgood's calculus text at about the same time that I began to develop for them Huntington's fundamental proportion, and soon one of them came to me and said that she was getting badly mixed up in trying to do my problems one way and her calculus course problems the other. Of course I told her that I didn't care how she did my problems, if only she could get the right answer by any legitimate method, and suggested that she do everything in the classical way. "But," she answered, "I *can* do them your way, and I *can't* his, and he won't let me change."

Perhaps the easiest way to present this subject is to outline it in much the same order that I should present it to an elementary class, but of course much more briefly. I shall probably include somewhat more material than should be covered in a high school course, but you can easily choose for yourselves what is suitable for your purpose.

In the first place, there is no question, I think, but that this subject should come at the very end of the mechanics part of the course, for it is undoubtedly harder for students than the simple machines, and even the mechanics of liquids and gases. I have always wondered why practically all the text-books have lumped the simple machines, the parallelogram of forces, and rigid body statics in general,

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into the same chapter with accelerated motion, and especially why such a chapter should come first.

So we may assume that the student is already familiar with the idea of force as something that stretches a spring balance, and with the parallelogram of forces. We should begin with a careful discussion of velocity or speed, including constant speed, average speed, and speed at a point. One way to present the idea of speed at a point is to remind the student of an automobile trap, and of the necessity of making it as short as possible, so as to avoid jockeying by a reckless chauffeur who discovers that he is in a trap. Then we should discuss acceleration in much the same way, except that it is not necessary to consider variable acceleration. All this should be done slowly and patiently, for it is the only essentially hard part of the subject. Next would come the three formulæ for motion with constant acceleration, and the familiar proofs of the fact that a free fall is a motion of this kind. And then the student would be ready for Newton's second law, which is where the novelty of Professor Huntington's treatment begins to appear.

Newton's second law is stated, I believe, more awkwardly in most text-books than any other fundamental proposition. Consider, for instance, the following, from one of the most popular physics texts now on the market:

Change of momentum is proportional to the impulse which produces it, and takes place in the direction in which the force acts.

How is an inexperienced student to make connections with such a statement as that? In the first place, before he can understand even what it says, he must get used to two entirely new concepts, namely "momentum" and "impulse," so that you are asking him to do three things at once, which is bad teaching. And in the second place, why should momentum and impulse be promoted to so prominent a place in the very foundation of the whole subject? You say that the student ought to take naturally to the idea of impulse, because the effect of a force is obviously proportional both to its magnitude, and to the time it acts. But its effect is just as obviously proportional to its magnitude, and to the distance through which it acts, and the work concept is far more important in physics than the impulse concept. Why base everything on the less important idea? Furthermore, of all the concepts in elementary mechanics, momentum is the one which I would omit first from a high school physics course if I were pressed for time. Most of the useful problems which can be done with its aid can also be done in other ways, except perhaps collision problems; and when does a boy see a collision problem in real life in such a form that a physics-book solution of it would make him one bit more skillful or more intelligent in meeting the real situation?

The gist of Newton's second law, as I see it, is twofold: *first, the*

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acceleration which a force produces in a body is always in the direction of the force; and second, if the acceleration produced by a force F_1 *is* a_1, *and if that produced by a second force* F_2, *acting on the same body, either at the same time or in a different experiment, is* a_2, *then*

$$\frac{F_1}{F_2} = \frac{a_1}{a_2} \text{ (I)}$$

This statement of Newton's second law involves only the two ideas of force and acceleration, which are really fundamental, and which are, moreover, already familiar to the student, if the preliminary work outlined above has been done thoroughly. Futhermore equation I is the simplest sort of a proportion; it appeals to a boy's instinct for reasonableness, and it is easy to grasp and to remember.

In celestial mechanics, the fundamental proportion is ordinarily used in just this form, but when we are dealing with smaller objects it is convenient to have a standard case with which to compare any case in which we may be interested. Now one of the easiest ways to cause a known force to act on an object is to let go of the object. In this special case the force acting is the weight, W, of the object, and the acceleration which it produces is g. So we can use W and g as two of the terms in the fundamental proportion, whenever it is convenient to do so. That is

$$\frac{F}{W} = \frac{a}{g} \text{ (II)}.$$

This form of the proportion enables us to compute the acceleration a produced in any given body by any assigned force F, or conversely, the force F required to produce any desired acceleration a.

Let us consider for a moment the question of units. You will remember that this is by far the hardest part of the classical presentation, for apparently boys seldom take kindly to either dynes or poundals, which are then indispensable. Here there is no need of either dynes or poundals. All we have to do is to express both F and W in terms of the *same* force unit, no matter what it may be, and both a and g in terms of the *same* acceleration unit, no matter what it may be, and we are perfectly safe. F and W can be in pounds, or in tons, or in ounces, or half-ounces, or grams, or kilograms, or penny-weights, or grains, just as is most convenient. Similarly a and g can be in ft./sec.^{2}, or cm./sec.^{2}, or in miles-per-hour per second, or in kilometers-per-hour per second*, as is most convenient. For that matter, it is a perfectly respectable procedure to put F and W in tons and a and g in metric units in the same problem if we want to. I remember that once, in that same Radcliffe class

* Incidentally, these are, by international agreement, the standard units of acceleration for steam and electric trains. Ordinarily we use either ft./sec.^{2} or cms./sec.^{2} because we do not remember the value of g in terms of any of the less familiar units, but this is merely a matter of convenience.

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of which I have spoken, we found in an English book a problem involving forces and weights expressed wholly in "stone"; we took a roll-call of the class to see what a stone was, and no two of us agreed; nevertheless, we all did the problem right without difficulty.

I have said that dynes are unnecessary in mechanics, but I suppose that in the present state of the college entrance examination situation, you will feel that you must teach your students what a dyne is. Furthermore, dynes are useful in one branch of physics, namely in the theoretical (but non-legal) definitions of the fundamental electrical units. Why not define a dyne perfectly frankly as being such and such a fraction of a gram-weight? Then give the student as one of his first few problems involving the fundamental proportion the following:—

"What acceleration is produced when a force of 1 dyne acts on a body weighing 1 gram? (N. B. The answer to this problem shows why the dyne was invented.)"

In other words, why not teach the student to regard the dyne just as he regards the grain or penny-weight, as an unfamiliar unit of force that is perfectly respectable, generally inconvenient, and occasionally indispensable in his dealings with life in general and examinations in particular.

Next would come work and kinetic energy. Let us assume that the student has studied simple machines in an earlier part of the course, and so is already familiar with the idea of work as force times distance in its own direction. The concept of kinetic energy should, of course, be introduced very carefully, with as much illustrative material as possible, before any attempt is made to evaluate it. This introductory material I need not go over here. All I shall try to do is to indicate to you, who are already familiar with the subject, how the equations look for the case of zero initial velocity.

We start with

$$\frac{F}{W} = \frac{a}{g} \text{ or } F = \frac{W}{g} a.$$

Since we want to evaluate the work done, we multiply this value of F by the distance s.

$$Fs = \frac{W}{g} \qquad as.$$

But we already know that

$$v^2 = 2as, \text{ or } as = \frac{v^2}{2}.$$

So

$$\text{Work done} = Fs = \frac{W}{g} \frac{v^2}{2} \text{ (III)}.$$

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If we have previously defined the kinetic energy of a body as the storage of work, this shows that the value of the kinetic energy is $Wv^2/2g$.

Here again the questions of units is the hardest part of the classical presentation. See how easy it becomes by this method. Since the two members of equation III are equal, the unit of energy is a *force* unit times a *distance* unit. Both Fs and $Wv^2/2g$ will automatically come out expressed in the *same* energy unit, if only we play the game *consistently*. To get any desired unit of energy, we have only to start with the corresponding force and distance units. If we want $Wv^2/2g$ to come out in ft.-lbs., we have only to put W in lbs. and v and g in foot-units. If we want $Wv^2/2g$ to come out in kilogram-centimeters, we have only to put W in kilograms and v and g in centimeter units. If we want $Wv^2/2g$ to come out in dyne-centimeters (that is, ergs), we have only to put W in dynes and v and g in centimeter-units; and so on. There is never any question as to when to put a g in the denominator and when to leave it out. There is always a g in the denominator, simply because there is always a g in form II of the fundamental proportion on which this form of the energy equation is based. Of course, when you come to do the arithmetic, sometimes the *number* 32.2 or 980 will cancel out, and sometimes it won't. But you don't have to tell a boy that. If he does not know enough by himself to cancel it out when he can, let him multiply it in and divide it out again. His answers will come out right enough that way, and bye and bye he will wake up, which is good for him.

When a class has handled the energy equation (equation III) for a while, one can go on to the broader general principle of the conservation of energy, and do as much with it as the time allows.

Finally, if I were going to handle impulse and momentum at all, I would put them last, and I would emphasize as much as possible both the similarities and the differences between the energy and the momentum idea. I suppose the two words "momentum" and "energy" are more often confused in the ordinary conversation of even educated men than are any other technical terms of physics except possibly "centripetal" and "centifugal," so that especial emphasis is required to train students to avoid this particular kind of illiteracy.

So far we have been dealing with the product Fs; why not see what we can do with the product Ft, which, for want of a better name, we call "impulse." Our line of attack is so much like that already followed, that it pays to put the work in parallel columns, thus:—

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Space investigation.	Time investigation.
$F = \frac{W}{g} a,$	$F = \frac{W}{g} a,$
$Fs = \frac{W}{g} as.$	$Ft = \frac{W}{g} at.$
But $v^2 = 2as$, or $as = \frac{v^2}{2}$,	But $v = at.$
So $Fs = \frac{W}{g}\frac{v^2}{2}$ (III).	So $Ft = \frac{W}{g} v$ (IV).
$\frac{Wv^2}{2g}$ is called kismetic energy.	$\frac{Wv}{g}$ is called momentum.

This emphasizes at once that the chief difference between equation III and equation IV is that one answers questions about *distances* and the other similar questions about *times*. Thus, suppose we know the weight and speed of a railroad train, and the retarding force when the brakes are applied. If we want to know *how far* it will run before stopping, we use the energy equation (III). If we want to know how long it will run before stopping, we use the momentum equation (IV).

At this point one could, if he wished, introduce the law of the conservation of momentum, and collision problems, but as I have said, I doubt if this is worth while, even in an unusually thorough high school course.

Here, as before, we should think out clearly the unit situation. This is especially difficult for students because the common momentum units are usually left nameless, but this is easily remedied. Just as equation III shows that an *energy* unit is always a *force* unit times a *distance* unit, so equation IV shows that a *momentum* unit is always a *force* unit times a *time* unit. What momentum unit we get when we blindly work out the numerical value of Wv/g, depends simply on what force and time units we started with. If we want Wv/g to come out in ton-seconds, we have only to put W in tons and v and g in second units. If we want Wv/g to come out in gram-seconds, we have only to put W in grams and v and g in second-units. If we want Wv/g to come out in dyne-seconds, we have only to put W in dynes and v and g in second units. There is no worrying about whether or not to put a g in the denominator; there is always a g in the denominator, and it always takes care of itself automatically, even if we want the momentum to come out in so-called "absolute units."

It has always seemed unfortunate to me that a dyne-centimeter should have a name of its own, namely "erg," while a dyne-second is left unprovided for. One is just as worthy of the honor as the other. Either some one should introduce a new name for the momentum unit, or, far better, we should drop the word "erg" for good, and use always the descriptive name dyne-centimeter.

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This finishes my presentation of uniformly accelerated straight line motion. Before you begin to discuss it, let me forestall one or two possible objections:—

One objection, very commonly urged against this theory of mechanics, even by such well-informed persons as the writer of a recent bulletin issued by the Bureau of Standards, is that the so-called "engineer's unit of force," the pound-weight, is a "variable" unit, and therefore beneath the respect of truly scientific men. The answers to this objection are two; first and foremost, that it isn't true, and second, that even if it were true, it wouldn't make as much difference as is commonly supposed.

Taking the second answer first, why should we object even if someone in Boston should find it convenient to solve his problems in terms of one unit of force, while someone else in Chicago was using another? There certainly would be no objection if the Boston man were using poundals and the Chicago man dynes. Why should there be if each should choose to use as his unit the "local weight" of a piece of platinum marked "1 lb."? The fundamental proportion holds for each man just as rigorously as ever, and each gets the right answers to all his problems if he plays his own game consistently. It is only when the two men wish to compare data, that they find different units of force inconvenient, and even then all that each needs is to know the size of the other's unit in terms of his own.

A much more fundamental answer is that, as a matter of fact, neither a Boston engineer nor a Chicago engineer ever does use the *local* weight of the "1 lb." lump of platinum as his unit of force. Each invariably uses its *standard weight* as his unit. The *standard weight* of any object can be defined as the pull of the earth on that object at any place where g has the value 980.665 $cm./sec.^2$, this value of g having recently been adopted as standard by an international agreement involving most civilized countries. The "engineer's unit of force" is the standard weight of the piece of platinum preserved in the Bureau of Standards at Washington and called the prototype pound, or that of a similar piece called the prototype kilogram, preserved near Paris. This unit is absolutely invariable, even though the local weight of the said piece of platinum may, and indeed does, vary considerably when it is carried from place to place. The statement that the engineer's unit is "variable" and "unscientific" is wholly false and misleading.

Not only are the pound and the kilogram units as scientific as the poundal and the dyne; they are also as convenient, even in work of the highest precision. Suppose we wish to determine the magnitude in standard pounds, or standard kilograms, of any given force acting in a laboratory, whether it be a push exerted by a rod, or an electromagnetic force in a motor. If we do not care for great accuracy, we have only to use a *spring balance* previously calibrated to read

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standard pounds or standard kilograms. The indications of such a balance are always in standard pounds or standard kilograms, no matter where the balance is used. If we want greater accuracy than a spring balance can give, we usually compute for comparison the value in *standard* pounds, or *standard* kilograms, of the *local weight* of some convenient object. For this purpose, we have as a special case of the fundamental proportion

$$\frac{W}{W_0} = \frac{g}{g_0},$$

where W and g are local weight and local gravity, and W_0 and g_0 are standard weight and standard gravity. W and W_0 are two different forces which exist, or might exist, in nature, *both* being expressed in terms of the standard pound or standard kilogram as a unit. The W_0 of any object is easy to determine anywhere by means of a *beam balance* and a set of standard weights; g_0 is 32.1740 ft./sec.^{2}, or 980.665 cm./sec.^{2}; and g, the local acceleration of gravity, can be determined by pendulum observations. So the value in standard pounds or standard kilograms of the local weight, W, of the object can be calculated, and the given force measured by some suitable means of comparison.

All this may seem complicated, but as a matter of fact, the steps are exactly the same as those required to determine the value of the same force in poundals or dynes. It is an unfortunate fact that inasmuch as g does vary as one goes about from place to place on the earth, both beam balance weighings and pendulum observations are necessary for precise work under any system of mechanics whatever. Once we have them, we can do work of the highest precision just as well in terms of standard pounds or standard kilograms as in terms of poundals or dynes.

Another possible objection is that I have not yet mentioned the word "mass." Frankly, I am inclined to think that it would be better never to mention it. The distinction between mass and weight is one to which no boy takes kindly, and as far as I can see, the mass concept is of little value even in advanced physics, and so is hardly worth the great trouble required to get it straightened out. It is true that it affords a convenient way of stating the principle of universal gravitation, but even that can be handled without it if necessary.

Let us see for a moment just what the mass idea is supposed to be good for. We know that any given body has some property which makes it hard for us to set it in motion: that is, it has inertia. It is as a measure of this inertia-property that the mass idea is commonly introduced. But this is not necessary. The standard weight, W_0, of the body is just as good a measure of its inertia as is its mass, m; indeed the two numbers W_0 and m are indentical.

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Why not then use a concept already familiar, namely standard weight, rather than a new and difficult concept, namely mass?

Of course, if anyone disagrees with me as to the importance of the mass idea, he can introduce it easily enough, even if he has used the fundamental proportion in the form here suggested. In doing so, it would be well to avoid the fallacy that all you have to do is to put $m = W/g$. If you try this, your unit of mass in the English system will turn out to be an unexpected thing, called by some a "slug" and by others a "wog," instead of the familiar pound. The corresponding unit in the metric system is, I believe, sometimes called a "g_0-kilogram." Neither of them is pleasant to handle. But except for this pitfall the road to mass is as clear by this method as it ever is, and he may travel it who likes.

May I suggest in closing, that in judging of the value of these ideas, you should separate carefully in your minds the questions of logical precision and usefulness. I think I can prove, if I have not already done so, that the proposed method is logically precise and rigorous. But so is the classical system, and so, on this ground, neither has any advantage. The whole question is, which is easier to use and to teach; which gets farthest with real boys and girls? That I must leave to you to judge, merely suggesting that here, as elsewhere, "the proof of the pudding is in the eating." Try it and see.

Lunch was then served in the basement of the High School.

AFTERNOON SESSION.

The afternoon session consisted of a talk by Reginald A. Fessenden on

Wireless Telegraphy and the Ether.

It is a matter of importance to the Commonwealth that this Association should exist and that these meetings should be held, for our well being depends upon our facilities for obtaining heat and light, on transportation, food supply, sanitation—all those things which form the wealth of the nation.

All of these were at one time non-existent, for the thoughtlessly coined phrase, "Natural resources of the Nation," represents nothing existent now or in the past, or capable of existence in the future, for all this wealth was originally latent and disclosed by men who were students of science, whether they did their work at home, in the shop, or in the laboratory.

As Germany has shown us, the great advances are no longer to be hoped for from untrained workers but from those who have been

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taught, *from the beginning,* in school as well as later on in college, familiarity with the fundamental facts of physics. And for the solution of most of our perplexing economic problems we must look, not so much to direct legislation, but rather to the indirect results of the work of those who are entrusted with the high office of imparting a knowledge of science in the schools.

How important this is, from a purely material standpoint, can be demonstrated by a single example, and very briefly.

The power obtainable from Niagara Falls is over 6,000,000 H. P., more than all the power generated in Great Britain. To furnish this power from steam engines would necessitate the consumption of over 60,000,000 tons of coal per annum. Estimate therefore as liberally as we may the amount of the coal deposits of the United States available for producing power, its amount is less than that obtainable from Niagara Falls taken over a very moderate number of years.

Therefore the men who, informed by Science, wrought the miracle of producing heat and light from falling water have added more to the wealth of the nation than Nature did when she laid down our stores of coal.

You teachers of Physics have, therefore, a high aim. Not the "knowledge for knowledge's sake" of the half-baked individual who snobbishly boasted that he "had discovered a branch of mathematics which could never be prostituted to any practical use" (and incidentally thereby disclosed his ignorance of the relations between different branches of mathematics, since for more than ten years Invariants have been put to use in mathematical physics) ; but that far higher one, of so grounding your students that when their time comes they may take effective part in the betterment of the world. And in so doing you are carrying on the work of such truly great men as Rowland, Rayleigh and Kelvin.

The "Apostolic Succession of Teachers" is an expression I have elsewhere used in discussing certain groups of great men, and there is historical evidence of the great benefits to be derived from the free interchange of ideas between men working toward a common end. We should make the most of such occasions as the present.

In my own small way I have endeavored to signalize the occasion by presenting to this meeting some results of my work which it was not intended to publish for some time, for at least a year. Such as they are, you have at least the advantage of knowing of them considerably in advance of the scientific societies and institutions.

The ones chosen relate to the matter in hand and are three in number.

The first is a new relation between certain of the physical constants of the ether. This relation appears to explain the phenomenon of gravitation and it enables us to calculate the velocity of propagation of a gravitational disturbance.

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The second is a purely electrical method of controlling large amounts of electric energy, instantaneously and without moving parts of contacts, by the inductive action of a circuit carrying a small amount of energy. While it is of very general use, it has been found especially valuable in that it enables the output of a high power station of over 100 K. W., to be modulated with great efficiency by a telephone transmitter circuit having an activity of only a few watts.

The third is a description, with photographs, of the apparatus built to telephone across the Atlantic, between Brant Rock and Machrihanish, Scotland. This has never before been described, and may be of interest.

Nature of the Ether.

Not every physicist is concerned with electric wave telegraphy, but the ether is of interest to all; there is, I think, no one who is not desirous of obtaining a clear-cut and accurate conception of the nature of the ether; and we will, therefore, take up this part of the subject first.

When people began to electrolyse chemical compounds they found that though 35 grammes of chlorine combined with 23 grammes of sodium and 108 grammes of silver, yet the amount of electricity on the 23 grammes of sodium was the same as that on the 108 grammes of silver. This indicated that the amount of electricity on each atom was the same, and this amount was called provisionally "the atom of electricity," or the "natural unit of electricity."

Now the size of the atom can be found with quite fair accuracy in a number of ways. One of the best is derived from the fact that when a drop of liquid is spread out into a film so thin that every atom is on the surface, half as much work has been done as would be required to separate all the atoms from each other entirely, *i.e.* to vaporize the drop. Now we know the latent heat, *i.e.* latent energy, of vaporation for many liquids, and also the surface tension, *i.e.* the ergs required to make one square centimeter of surface. So by dividing the latent heat of vaporization of a cubic centimeter of liquid, expressed in ergs, by the surface tension, also expressed in ergs, we get twice the area in square centimeters which the film would have if the drop were spread out so that every atom were on the surface, and the thickness of that film will be twice the atomic diameter.

In a paper published in the *Physical Review* (January and March, 1900) I have given the results obtained for mercury. The diameter of the mercury atom is found to be 2.79×10^{-8} cms.

Knowing the diameter of the atom. we can find how many atoms there are in a cubic centimeter. And knowing how much current is required to electrolyse a cubic centimeter of mercury, by dividing

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that amount by the number of atoms in a cubic centimeter we get the amount of the electric charge on each atom.

This amount, the "natural unit of electricity," is found to be very closely 4.10^{-10} electrostatic units.

Long ago that wonderful genius Faraday had predicted that if we ever ascertained the nature of electricity it would be through experiments on the discharge of electricity through gases, and it was while working along this line that Sir Joseph Thomson discovered the existence of particles of matter much smaller than the atom, but carrying always this same unit of electricity.

He determined the ratio of the electric charge to the mass, *i.e.* the ratio e/m, by placing them in a combination of an electric and magnetic field, so that the electric field should carry them along in one direction, giving the mass a certain amount of momentum, while the magnetic field should sweep to one side, owing to the reaction between the moving charge and the magnetic field. By adjusting the electric and magnetic field so that the charges were swung aside so that they just did not touch a plate connected to an electrometer, he was able to calculate this ratio.

Knowing the ratio and the value of the unit quantity e, he was able to calculate the mass m of this small particle of matter, called by him the corpuscle. It was found to be 10^{-27} grammes.

Later on the value of the electric charge was determined in the most direct and positive manner, by shooting a single corpuscle or electron through a small hole, so that it fell on a plate connected to a sensitive electrometer, where it could be measured directly. The value so measured agreed very closely with that calculated.

The next point of interest is this. In the 1900 *Physical Review* paper above referred to I had shown that certain electric and magnetic phenomena proved in the most conclusive manner that

"*The total area of the space occupied by the atoms to the exclusion of other atoms is very large compared with that of the atoms themselves*, i.e. *that the atoms have a configuration virtually equivalent to that of small framework structures of thin platinum wire interpenetrated by oil.*"

This conclusion was not generally accepted, so that when Thomson's striking discovery of the corpuscle was published it was left to the writer to discover that the size of the corpuscles was such that the electromagnetic inertia of the moving charge was identical with that of the known inertia of the corpuscle, *i.e.* that mass was simply electromagnetic inertia. The result was published in the *Electrical World*, April 7, 1910.

It was still uncertain, however, whether the entire mass of the corpuscle was electromagnetic or whether a part of it might not be of a different character. The question has since been settled by Thomson, who from a comparison of Kaufmann's results for corpus-

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cles moving with different velocities has determined that the entire mass is electromagnetic.

Knowing this, we are now able to determine quite closely (all the figures here given have a probable error of not more than 25%) the diameter of the corpuscle, from the formula.

Electromagnetic inertia of charge $= 2/3 \times$ charge $\div$ radius, and we find it to be 10^{-13} cms.

From which again we get the density of the corpuscle as 10^{13} times that of water.

We can see in a Crookes' spintharascope each little flash of light as each individual corpuscle strikes the screen. We can hear it by other apparatus. The luminous trajectory of individual corpuscles as they fly through a gas, striking the molecules and causing them to emit light can be seen and photographed. We know its diameter, its density, its mass, and the amount of the electric charge.

So that an electron is not a hypothetical thing at all. It is a very real thing, as much so as a brick.

These electrons are, so to speak, the bricks of the universe. The ether and matter are built up out of them.

Electrostatic Doublets.

Many years ago, in 1887, I showed that a unit positive charge and a unit negative charge combined together to form what I called an electrostatic doublet, which possessed the following properties:

1. Electrostatic doublets attract each other with a force varying as the inverse fourth power of the distance between them.

2. A body formed of a mass of such electrostatic doublets has a modulus of volume elasticity given by the formula

$$\frac{8.10^3}{v^2}$$

where v is the volume of the doublet.

(Note—References to these papers, from 1887 on, will be found in the *Physical Review* paper above referred to.)

Electrostatic Doublets and Matter.

It was then shown, in the same paper, that the Young's modulus, rigidity, tensile strength, surface tension, etc., could be deduced from these laws, each atom constituting an electrostatic doublet whose moment is equal to the product of the ionic charge by the diameter of the atom.

This theory has now been accepted by such eminent authorities as Sutherland (Phil. Mag., May., 1909) and Lodge and a large amount of evidence has been accumulated in its support.

The following table, taken from the original papers, shows the close agreement of the theory with observation.

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Metal.	Young' s Mod. ÷ 10		Atomic Volume.
	Obs.	Calc.	
Iron	2,000	1560	7.1
Copper	1,220	1560	7.1
Zinc	9,930	920	9.2
Silver	740	750	10.2
Cold	760	750	10.2
Aluminum	680	690	10.4
Cadmium	480	465	13.
Magnesium	390	395	14.
Tin	420	295	16.3
Lead	190	235	18.1

I may say that the figure for magnesium was predicted in advance of the measurement, and the prediction was verified by Professor Thurston of Cornell.

Incidentally it may be mentioned that from this theory the following law was deduced, and found to be very closely in accordance with the facts,

The relative conducting power for electricity of equimolecular wires of different metals is proportional to the time taken by sound waves in traversing them.

This is because the rigidity of the metals depends upon how many electrons there are in unit volumes, and so also does the ability to carry electric currents.

Electrostatic Doublets and the Ether.

It has recently been found that the ether is not continuous. For example, when a light-wave diminishes in intensity it does not die down indefinitely but at a certain point say three electrons are affected, then there is no diminution till later only two are affected, and so on. So for this and other reasons it seems to be clear that the other possesses some kind of atomic structure.

To show clearly what that structure is and how it gives rise to gravitation we must first consider the electric and magnetic properties of the ether.

Electric and Magnetic Properties.

All electric and magnetic phenomena are defined by the following four equations:—

1. $P / Q = k^{\frac{1}{2}} / u^{\frac{1}{2}}$
2. $QP = ML^2 / T$
3. $k^{\frac{1}{2}} u^{\frac{1}{2}} = T / L$
4. $P / u = M / LT$

The first is derived from Coulomb's laws for the attraction of units of electricity and magnetism, the second from Faraday's and Weber's laws, the third represents Maxwell's law, and the fourth from some electrical phenomena described in the *Physics Review* paper referred to above. It may be more simply derived from the consideration that

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conductivity is expressed by the volume density of electricity and nothing else, since the other factors cancel out.

(Note:—Qualitative mathematics differs from dimensions in that dimensions relate merely to ratios of units, while qualitative mathematics gives the complete specification of their nature.)

Having four equations for the four unknown quantities, we can determine them. We find

1. That Q (quantity of electricity) is mass times angular velocity. I hope later to give the results in full of some experiments made by firing bullets from a rifle parallel to one leg of an electric circuit containing a ballistic galvanometer. As this paper is to a certain extent informal I may say that the results appear to indicate that a 12-inch shell fired at a velocity of 3,000 feet per second is about equivalent to a tenth of a milliampere or to a moving static charge of several electrostatic units. This statement may have to be revised, as it is barely possible that the effect may be due to an electric charge due to friction, and I have not yet been able to obtain a gun with reverse rifling. So for the present no definite statement can be made, but the reference to the experiment will help to explain the nature of an electric charge.

Looking at it from the vortex theory standpoint, an electron is a sort of kink in the vortex. When the kink slides along we have a current.

2. That P (quantity of magnetism) is merely a ratio.
3. That k (specific inductive capacity) is density.
4. That u (permeability) is the reciprocal of elasticity.

We have seen that the ether must have an atomic structure, and as light passes through it and light is an electric wave, the atoms of the ether must have an electric character. From experiments on the dampening of spectra I have been able to show that the density of the ether must be approximately the same as that of the electron, *i.e.* 10^{12}. Knowing the velocity of light and the density of the ether we can ascertain its rigidity to electric disturbances, and find it to be 10^{33}.

That the ether should have such great rigidity, and therefore such great density, is at first surprising. But when we remember that Maxwell long ago showed that the ether must be at least 10,000,000 times stronger than the strongest steel in order to stand the gravitational stress near the sun's surface without tearing apart, we realize that these characteristics of the ether were to have been expected.

Thus we have arrived at an ether, having a density a million million times that of water, a rigidity of 10^{33}, electric in character and having an atomic structure. What is the nature of this structure?

Gravitation.

Electrostatic Doublets and the Ether.

Since energy of strain depends on configuration and modulus of

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elasticity and we know the configuration, we can proceed to calculate what the modulus of volume elasticity must be of a medium which will give the observed amount of gravitational energy.

The formula which I have derived is

$$\text{Modulus} = \frac{2nG^2}{rW}$$

where G is the gravitational constant, r is the radius of the electron, and W is the gravitational energy of the electron. The value obtained is

Volume elasticity of the ether $= 10^{44}$.

These figures were given by me in a paper published in 1900 (*Science*, November 16, 1900).

The new relation which I have discovered is this: If we take an ether composed of positive and negative corpuscles, forming electric doublets, and apply the same formula, *i.e.* $10^{24}/\text{radius}^2$, we find that the rigidity of this ether is 10^{44}.

In other words, the volume elasticity of the ether, due to its being composed of corpuscular electric doublets, is exactly that required to give the observed effects of gravitation.

We may now calculate the velocity of a gravitational impulse, by the well known formula for such cases. It comes out as approximately 10^{16} cms. per second.

This is much faster than light, as it should be. It explains very satisfactorily a number of outstanding difficulties, for example, why there is no compressional wave energy lost in transmitting light, for the fraction lost is only 10^{-10}, *i.e.* quite inappreciable.

Whether our astronomical instruments are sufficiently accurate to detect a velocity of 10^{16} cms. per second in connection with, for example, the satellites of Jupiter, I do not know. Now that the amount to be looked for is known it might be of interest to astronomers.

Two Elastic Moduli of the Ether.

It will be noted that the ether has two elastic moduli, of quite different dimensions.

First, the modulus to electromagnetic disturbances, value 10^{23}.

Second, the volume elasticity of gravitational modulus, value 10^{44}. This is, however, not new. Long ago I had discovered it, as the result of investigations along entirely different lines, and in the *Physical Review* paper referred to (January and March, 1900) had pointed out that the ether "behaved like rubber" in that its modulus of rigidity and its volume elasticity modulus were "of quite different orders."

This can be explained by the following illustration: Take a long iron rod and place an observer, with very sensitive magnetometer and seismograph at the other end. Approach suddenly to the near end a magnetic pole. The attraction of the iron rod to the pole will

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cause an elastic wave to travel to the far end with the velocity of sound, say 4,000 feet per second, and record itself there. At the same time a magnetic wave will travel along the rod, and if the rod be sufficiently permeable and conductive its velocity will be only a few feet per second. So the electromagnetic modulus will come out very much smaller than the cohesion modulus.

Now when light travels through the ether it is analogous to the magnetic wave mentioned above, and the rigidity to electromagnetic disturbances of the ether is only 10^{33}.

But when a gravitational wave travels through the ether, its velocity is determined by the resistance to compression, *i.e.* to the cohesion modulus, which is 10^{44}. So it travels very much faster.

I would like very much to go into the matter of positive and negative electrons, and to point out the probable reason why the positive electron has so much greater mass than the negative one, but this would be outside the scope of this paper, so we will next take up the way in which electric waves are generated, and as the paper is already rather long, will do so very briefly.

Generation of Electric Waves.

(Here followed a description of different types of antennæ and of the different modes of charging them.)

When the wire is charged one end of each electrostatic line ends on the wire and the other on the ground. As the area of the ground is much greater than that of the wire the side thrust $\frac{D^2}{8uk}$ is much greater on the wire than on the ground. So when the gap breaks down the ends which are on the wire are pushed down much faster than the ends on the ground are pushed in, and as all lines have the same amount of sideways inertia, the ends of the wire are driven down past the gap and form half hoops on the ground. Then the sideways repulsion sends them outwards.

(Then followed a description of the effects of atmospheric absorption and of the writer's discovery of the fact that waves over 3,000 meters long are not absorbed.)

These waves are not, however, true electromagnetic waves in the ordinary sense, nor do they fall off with the square of the distance. The true law was communicated by me to Professor Max Wein, in 1908. It is as the fourth power of the distance. This is why, though it only takes one watt to telegraph 100 miles, it takes nearly 1000 kw. to go 3,000 miles.

(Then follows an account of the author's 35-kw. 50,000 cycle alternator and the other apparatus constructed for transatlantic telephony, but never put into use on account of disagreements between the company officials.)

One thing appears to have excited considerable curiosity, and that is the means employed to modulate such large powers as 35 kw. by means of the voice. It is perhaps unnecessary to say that an entirely new method, in fact an entirely new electric principle, had to be dis-

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covered before this was possible, and, I have great pleasure in making the first disclosure of it to your Association.

In using a telephone transmitter to modulate the radiation from an antenna, it is a matter of indifference where it is connected, as in every case it has to absorb just one half the total energy. If the source generates one kw. the transmitter must absorb one-half kw., and this heat must be got rid of. This is about the limit possible for a telephone transmitter able to distinguish between the words "fix" and "six," *i.e.* to give first class articulation. Received on a 150-foot mast this one-half kw. sending station will give telephone transmission of grade A over a distance of 180 miles, in daylight, in summer, and reliably. This was proven by a ten months' test between Brant Rock, Mass., and Brooklyn, N. Y. It will give grade B over a distance of 425 miles, as shown by tests between Brant Rock and Washington. Of course on freak nights much longer distances can be accomplished, and we have had well authenticated reports from Nebraska, from Jamaica, from Panama, and on two nights our Machrihanish operators were able to take down the wireless telephonic instructions which were being given by our Brant Rock to our Plymouth station, during the winter of 1907. But these were quite exceptional, and in calculating out the power for the proposed daylight transatlantic communication it was found that at least 35 kw. would be needed.

The photograph shows the 35-kw. 50,000 cycle machine built. Relays were at first tried, but found to be impracticable to handle that amount of energy. Finally, as the result of a purely mathematical investigation which I was making along quite different lines I was led to the discovery of a circuit having very peculiar properties and, fortunately, just adapted for my purposes. It is shown in the figure.

Here 1 is the main circuit carrying 35 kw. It divides into two branches, as shown. The two coils 2 and 3, of which one is in one branch and the other in the other branch, have the same number of turns, and are of very low resistance and considerable inductance when separated. But when placed side by side they have extremely slight magnetic leakage, in fact they are in practice wound with a twin conductor of flat multiple and spiralled wires, and the direction of the winding is such that when the same current flows through both they annul each other's inductance. The telephone transmitter is shown at 4, in one of the branches, but in practice it is a differential one, one side in one branch and the other in the other. The two branches, after uniting, pass through a capacity 5 and an inductance 6, which may be split and put in each branch if preferred.

The resistance of 4 is normally such that the same current passes through both branches, and the coils 2 and 3 offer no impedance to the circuit, which is tuned by 5 and 6. But when the resistance is changed very slightly the impedence of 5 and 6 becomes quite large

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and the current is greatly diminished by the throwing out of tune. At the same time there is a peculiar swinging or reversal of the currents in 5 and 6, which may even change sign, and may increase to ten or fifty times their previous value, causing great loss through ohmic resistance.

In practice the transmitter is placed generally in a circuit inductively connected to one of the branch circuits, or both, and the net result is that the modulation of a current of one-half kw. activity by the transmitter has been caused to effect the modulation of 100 kw. in the main circuit.

It will be seen that the circuit is very simple and that as it acts purely inductively there is no lag due to moving parts of contacts. To those wishing to duplicate these results I would point out that it is very important that the ohmic resistance of the circuit should be kept very low.

Many interesting views of the Brant Rock station and the apparatus located there were thrown on the screen by aid of the reflectoscope.

After Dr. Fessenden's talk tea and light refreshments were served in the Domestic Science room, where those present were hospitably received by Miss Lillie Smith of the Science Department of the High School. The cooking was done on electric apparatus loaned by the Simplex Company of Cambridge.

A vote of thanks was extended to the speakers of the day and to those of the High School, whose efforts had been the means of a most successful meeting.

The remainder of the afternoon was given over to an inspection of the laboratories and buildings about the playground.

Through the kindness of Milton B. Sleeper and John B. Starkweather, of the Newton High School, some were enabled to watch the transmission and reception of messages on the apparatus of the Brookline High School.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SIXTY-FOURTH MEETING

OF THE

Eastern Association of Physics Teachers

at Wentworth Institute

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Saturday, March 29, 1913

Morning Session

9.30 A. M.
Meeting of Executive Committee.

10.00 A. M.
Address of Welcome by Principal Williston of Wentworth Institute.

10.15 A. M.
Business.
Annual Report of the Secretary.
Annual Report of the Treasurer.
Reports of Standing Committees:—
On New Apparatus. John C. Packard, Chairman.
On Magazine Literature. G. G. Bulfinch, Chairman.
On Current Events in Physics. F. H. Hadlock, Chairman.
On New Books, Clarence M. Hall, Chairman.
Election of New Members.

11.00 A. M.
"The Screw Propeller." Professor Ira N. Hollis of Harvard University.

12.00 M.
"The Beginnings of the Telephone." Thomas A. Watson, Braintree, Mass.

1.00 P. M.
Election of Officers.

1.30 P. M.
Lunch.

Afternoon Session

2.30 P. M.
"Applied Science at Wentworth Institute." W. H. Timbie, Head of Physics Department.

3.00 P. M.
Inspection of laboratories, shops and other places of interest at the Institute.

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MORNING SESSION.

The meeting was called to order by President Griswold, who in a few remarks introduced Principal Williston of Wentworth Institute. In his address of welcome, Mr. Williston spoke of the pleasure that was his in welcoming the members of the Association in behalf of the directors and faculty of the Institute, as well as personally. He wanted us to feel that we were glad to come and see what is being done at the school. Briefly referring to the past, he pointed out how interesting it is to look back over the years of social evolution, and notice how civilization has moved forward in periodic waves of art, exploration and discovery, drama, religious enthusiasm and politics; and that we are now in the midst of an educational renaissance. At the present time there is sweeping over the country an unquestionable tendency to make secondary education for youth from fifteen to twenty years of age meet better than ever before the community needs. It is a period of transition and suspended judgment. A most remarkable phenomenon appears in the wonderful complexity of modern society. This demands many types of schools to meet the many kinds of needs. There was a time in the days of Ancient Rome when the calling of the soldier was the only one worthy of serious consideration; then followed the cloister growth of education. Those days are gone and the tendency of today is away from education for culture alone. To be able to *do* things is the aim. The possibilities of such a training are broad indeed. President Eliot has pointed out the great value of incentive in a life career; and development of ways of using that incentive to give vitality to education is what should be sought.

Wentworth Institute has taken upon itself to deal with a few of the multitude of things that might be studied. A particular group of young men are taken, with the idea that *all* their natural abilities are to be devloped. Out of these it is sought to make more skillful, intelligent mechanics in their respective lines. The power of human leadership is developed in some who have already had practical experience, so as to train them to become foremen and master mechanics. In this, however, development of mechanical skill (for the purpose of getting best wages) is not the whole object; for through this, interest in outside correlated subjects is aroused, and a liberal education given to the student.

The motto of the school might be said to be to teach a few things well, and at the same time try to bring out as many other things in the pupil as possible.

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In the matter of science the object is not to teach the whole subject, but to pick out such parts as fit the needs of the individual case, and then deal with that part as a thing in itself.

The annual report of the Secretary follows:—

REPORT OF SECRETARY.

There have been three regular meetings of the Association, as follows:—

Saturday, March 2, 1912, at Massachusetts Institute Technology.
Saturday, June 1, 1912, at Charlestown Navy Yard.
Saturday, November 23, 1912, at Brookline High School.

At these meetings visits have been made to the Christian Science Monitor Publishing Plant and to the Christian Science Church, the Arena and its ice manufacturing plant, and the various points of interest in the navy yard.

At these meetings addresses and lectures have been delivered by the following men, not members of the Association at the time: Dr. H. C. Hayes, of Harvard; Prof. William J. Drisko of the Massachusetts Institute of Technology; Commander S. V. Kittell and E. T. Pollock, of the United States Navy; and Reginald A. Fessenden, of the Brant Rock Wireless Station. These addresses have been of a high order, and have kept up the high standards set previously.

There has been a slight dropping off in both the Active and Associate membership, which at the present time consists of 77 Active and 67 Associate.

Respectfully submitted,

ALFRED M. BUTLER, *Secretary.*

March 29, 1913.

The annual report of the Treasurer follows:—

REPORT OF TREASURER.

Receipts:—

Balance March 2, 1912	$119.98
Dues	316.00
Scientific American	35.60
School Science	78.00
Popular Mechanics	7.50
Electrician and Mechanic	2.00
National Geographic	4.00
Popular Electricity	4.40
Technical World	1.00
Lunches	26.50
	$594.98

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Expenses:—

Printing Reports, Manual, Notices	$148.35
Secretary	30.00
Postage, Envelopes, etc.	52.59
Scientific American	35.60
School Science	79.50
Popular Mechanics	7.50
Electrician and Mechanic	2.00
National Geographic	4.00
Popular Electricity	4.40
Technical World	1.00
Lunches	26.50
Balance, March 29, 1913	203.54
	$594.98

Respectfully submitted,
PERCY S. BRAYTON, *Treasurer.*

Examined and found correct.
CLARENCE BOYLSTON, *Auditor.*

March 29, 1913.

REPORT OF THE NEW APPARATUS COMMITTEE,

John C. Packard, *Chairman.*

Mr. Harrington of the Newton Technical High School showed a wave tank, consisting of a large piece of plate glass about two feet by three feet, inserted in a wooden frame two to three inches thick. In this water is placed to a depth of about a half inch and an arc light placed about two feet below, so as to throw light upwards through the glass. Light from this may be allowed to strike the ceiling, or be reflected to the wall of the room by a mirror at forty-five degree angle with water surface. If now disturbances are set up in the water, the train of waves arising from this may be plainly shown passing across the tank. As the arc light is a very small source of light, the outline on the wall will be quite sharp. The reflection of waves, both from plane and curved surfaces, representing mirrors, can be remarkably shown. By setting up the disturbance at different points with reference to a curved strip of metal representing a concave mirror, the different effects always studied in connection with that type of mirror can be very clearly shown. Also, if glass plates cut to the shape of the cross section of concave and convex lenses be used, and the water poured over them so that the surface is about an eighth of an inch above the top surface of the glass lens section, the phenomenon of refraction is well shown, as here the wave at the surface is retarded by the

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glass below. If the trough is tilted so that one side is out of water, a disturbance set up by successive points in a row, while producing a wave front oblique to the side of the trough, this becomes parallel with the side through the unequal shoaling effect, as it crosses the trough.

Mr. Harrington also displayed a piece of apparatus to show the electromagnetic effect of coils. This consisted of two vertical, parallel 12-inch coils of 20-30 turns, placed about a foot apart with a glass horizontal plate extending between them half way from top to bottom. On this were placed a number of small compasses with glass top and bottom so that light can pass through. (These can be bought from supply houses). The arc light was placed below, as before, and shadows of compass needles thrown on the wall. By slowly increasing the current through the coils the magnet group was disturbed more and more, until with a current of about ten amperes all pointed perpendicular to the planes of coils. When the current was gradually weakened, the magnets did not all go back as they were originally, showing a change brought about by the current.

Mr. Packard spoke of a Colt automatic arc lamp that can be secured of A. T. Thompson, and which he has found very reliable.

He spoke of the difficulty he had in finding sound apparatus that correlated with daily life; that he found his pupils most interested on the side of music. With this in view he had prepared a number of slides which can be secured of A. T. Thompson at thirty-five cents. Many of these were made from pictures found in musical instrument catalogues, of which the Wonderbook Series of four books, issued by Ditson, were found exceedingly interesting. He referred to a book called, "Sound in Relation to Music," that can be purchased at Ditson's.

Finding great difficulty in getting any conception of the meaning of a tone outside of the ordinary scale when spoken of in reference to vibration frequency or scale, as shown on sheet music, he said that he decided that by using a pianoforte keyboard as his reference he could get some idea of the matter. With this in mind, he had printed some plotting sheets with a keyboard diagram at the top and a line extending down the page from each key. The title of the sheet is "Musical Sounds' Range," a copy of which can easily be secured for the asking. Many interesting things can be done with this, such as showing between what notes lies the range of soprano, alto, tenor and bass; what notes the different strings of instruments cover; the noises of insects (which lie outside the range of the pianoforte).

He mentioned the use of the chromatic pitch pipe as much more practical than the tuning fork as a standard of sound, since the pianoforte is not tuned according to the scientific standard of pitch.

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REPORT OF THE COMMITTEE ON MAGAZINE LITERATURE,

G. G. Bulfinch, *Chairman.*

November, 1912, to March, 1913.

American Magazine. March, 1913. "Wrecks—Why They Increase."

Century. December, 1912. "The End of The Big Job."

Electrical World. Vol. 61, No. 1. "Developments in Electricity During 1912." No. 2. "Demagnetization and Recovery of Permanent Magnets." No. 3. "Wireless Telegraph Station at Fort Meyer, Va." No. 5. "New Method of Timing Watt-Hour Meters." No. 8. Precipitation of Smoke and Suspended Dust by Electrostatic Methods." No. 9. "Application of Hyperbolic Functions to Electrical Engineering." No. 10. "Acetylene Electric Flame."

Harper's Weekly. January 25, 1913. "Triumphs of the Bridge Engineer." "Three Stages in the Wonderful Electrical Development of Chicago."

Popular Electricity. December, 1912. "The Power Behind the Phone" (A trip through Western Electric Company's plant), H. Bedford-Jones. "In the Copper Country," George F. Worts.

January, 1913. "A Matter of Achievement" (An account of a trip through the Westinghouse manufacturing plant at Pittsburg), H. Bedford-Jones. "Formalities to be Observed in Connection with the New Wirless Law," Philip E. Edelman.

February, 1913. "The Wonder Work of the Mohawk Valley" (An account of a trip through the Schenectady works of the General Electric Company), H. Bedford-Jones. "Electricity Ousting the Steam Locomotives," Edward Lyell Fox. "Light: Its Use and Misuse." "Behind the Scenes in a Moving Pictue Theatre," Bennett W. Cooke.

March, 1913. "From Ingot to Wire," H. Bedford-Jones.

April, 1913. "The Faraday Centenary." "The Simplicity of Quality" (Account of a trip through the Simplex Manufacturing Company's works at Cambridge), H. Bedford-Jones. "Elemencary Electricity for Practical Workers," W. T. Ryan.

Popular Mechanics. December, 1912. "Smoke—A Problem of Today," by W. D. Harkins. "Wonders of Light. X. The Flying Electrons," by J. Gordon Ogden, Ph.D.

February, 1913. "Wonders of Light. XI. The Glory of the Firmament," by J. Gordon Ogden, Ph.D.

Popular Science Monthly. March, 1913. "The Laboratory Method and High School Efficiency," by Prof. O. W. Caldwell (University of Chicago).

School Science and Mathematics. November, 1912. "An Experiment in Organizing a Course in General Science," by E. D. Huntington.

December, 1912. "The Tangent Galvanometer in the High School Laboratory," by C. L. Vestal.

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March, 1913. "Science in the High Schools, An Investigation," by W. Whitney (Chicago). "A Unique Demonstration of Boyle's Law," by A. E. Hennings. "Note on a Device to Illustrate the Path of a Projectile," by J. H. C. Bagby (Virginia).

Science. March 7, 1913. "Physics and Daily Life," by Prof. C. R. Mann.

Scientific American. November 9, 1912. "Panama Canal—The World's Greatest Engineering Work."

November 23. "A Simple Rule for Determining the Direction of Gyroscopic Forces," by Assistant Professor Ed. Huntington (Harvard).

December 21. "Sending Photographs Over a Telephone Wire—The Improved Bêlin Apparatus," by Jacques Boyer.

January 11, 1913. "Will the Automobile be Driven by Kerosene?" by H. A. Morris.

February 15, 1913. "The Evolution of Worlds. The Work of Sir George H. Darwin," by J. W. N. Sullivan.

March 8, 1913. "What is Matter?" (The Individual Molecule Revealed). "Optical Illusions."

March 15, 1913. "Power from Kerosene," by L. W. Ellis and W. R. Dray.

Scientific American Supplement. November 16, 1912. "Cosmical Problems. Their Influence on the Development of Spectrum Analysis," by Prof. Wolf-Königstuhl.

November 30, 1912. "Sir William Ramsay,—Famous for His Researches on Helium and the Other Rare Gases of the Atmosphere," by Prof. W. Ostwald. "The Sources of Energy Available to Man," by Prof. J. A. Fleming.

February 8, 1913. "The Reality of Molecules. A Resumé of the Overwhelming Experimental Evidence Gathered Within the Past Decade," by Prof. T. Svedberg.

February 15, 1913. "Power from Kerosene," by L. W. Ellis and W. R. Dray. "Photographing Sound," by Prof. A. L. Foley and W. H. Sonder.

February 22, 1913. "Conservation and Research ("Economics Secured by Scientific Investigation"), by H. T. Kalmus. "Aviation Today," by Capt. W. I. Chambers, U. S. N.

March 1, 1913. "Modern Pumps for High Vacua," by E. N. daC. Andrade.

March 8, 1913. "The Birth of the Atom." "Triatomic Hydrogen and Other Researches in Molecular Physics, Sir J. J. Thomson's Latest Report." "Counting Atoms by Scintillations" (How the Individual Atom is Made Visible), by E. Marsden.

March 15, 1913. "Electricity and Chemical Action," by Prof. H. C. Jones. "Modern Microscopical Optics" (The Limitations of the Microscope), by C. Metz.

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Technical World. January, 1913. "First Storage Battery Train," by Burton Miller.

World's Work. December, 1912. "Exploring Other Worlds. I. Discoveries Among the Stars," by W. B. Hale.

January, 1913. "Exploring Other Worlds," II (Concluded), by W. B. Hale.

March, 1913. "The Day's Work of the Mt. Wilson Observatory," by G. E. Hale.

Report of the Committee on Current Events in Physics.

F. H. Hadlock, *Chairman.*

The Talking Moving Pictures.

The Edison kinetophone has been recently exhibited in the prominent theaters of New York and also in other large cities. In the first film a man makes a speech explaining the perfecting of the talking picture by Edison in the obtaining of absolute synchronism between the picture and the sounds. Then a pianist plays, a bugler sounds reveille, a young lady sings and, lastly, some dogs appeared and barked. The dogs give the most striking and natural demonstration of the new apparatus. A second picture shows a minstrel show in which the various members of the troup perform as naturally as in real life, though there was no mistaking the fact that the talk and music were produced by a phonograph. The intensification of the sound necessary in a theater apparently gives to it more of that metallic quality of which it has been successfully deprived in the smaller drawing-room machines. Nevertheless, it is no more disagreeable than the voices of many of the actors who appear on the vaudeville stage. The present talking pictures last about five minutes each, although a French machine has been perfected in which each film runs three times as long.

Picture Telegraphy Across the Atlantic.

Although the Berlin scientist, Dr. Korn, is having good success in sending photographs by wire between stations located at Paris, Berlin and Monte Carlo, for use in press work, he wishes to apply his method over a much longer distance. In fact, it is possible to send the photographs by mail between Paris and Berlin, for instance, in a comparatively short time, so that the newspapers are not as likely to take up a picture transmitting scheme as when they are a long distance from the center of events. For this reason he expects to take up the question of operating upon the Atlantic cable, and is confident that he will be able to send across the ocean. He is also considering the matter of coming to America in order to apply the system to a line between New York and San Francisco.

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New Gyroscopic Compass a Success.

A board of naval officers appointed to test the new gyroscopic compass, which was installed experimentally on the destroyer "Worden," have found it to be remarkably free from oscillation due to rolling and pitching of the vessel. Experiments which have been made with the same compass aboard a submarine show that it enables a helmsman to steer a more accurate course when the vessel is submerged.

A Sun-Power Plant in Egypt.

At Meadi, a suburb of Cairo, is a sun-plant of unusual interest. It consists of five reflectors, each 204 feet long, whose cross-section is in the form of a parabola, with the generator units at the focus. The last named are of zinc, built of rectangular sections 14 inches wide. To render them efficient they are painted with a black paint of high heat-absorbing capacity. The water is introduced at the lower end and the generator at its upper end is provided with a steam connection four inches in diameter. The reflectors are silvered glass mirrors. The plant works best at a pressure slightly below the atmosphere.

Improvement in the Steam Turbine-Generator.

A distinguished British electrical engineer announces some very promising experiments in obtaining higher efficiency for the steam turbine, so increasingly employed in electric generating plants. The new method consists in re-superheating the steam after it has passed through one of the stages of the turbine, and using a high temperature, the latter being rendered possible by coating the steel blades with sheet nickel. A 5000-kilowatt steam-turbine generator on this system was found to consume only seven pounds of steam per shaft horse-power. A still better performance is expected, namely, six pounds per H.P., or a thermal efficiency of twenty-four per cent.

Liquid Air.

The Harvard chemical laboratory is ready to furnish liquid air to schools for demonstration purposes. The price is $5.00 per liter, for first liter, $3.00 per half liter. Information may be obtained from Arthur B. Lamb, director of chemical laboratory.

Liquid Oxygen.

Liquid oxygen may be obtained from The New England Oxygen Association, 135 Pierce Street, Malden, Mass. The price is $2.00 for about one and one-half liters. Their plant has a capacity of three gallons per hour, and will liquify the air in fifteen minutes after starting the compression pump. The nitrogen is evaporated off, then the oxygen is evaporated and stored under pressure in tanks and

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sold. This end is the main part of their business. The liquid oxygen is merely incidental.

A new record of height was made in aviation in France recently, between 18,000 and 19,000 feet.

Report of Committee on New Books,

Clarence M. Hall, *Chairman.*

"Elements of Electricity for Technical Students."

By W. H. Timbie. Published by John Wiley and Sons, New York, 1912.

This book is to meet the needs of students preparing for the electrical industries.

It is intended for use in High Schools, Trade Schools and such institutions as Wentworth Institute.

The book is an excellent example of a clearly explained text by a teacher who is a master of his subject.

While the order of topics may not be strictly logical, the author can justly claim to have produced a teachable book.

The method of presentation is to make the maximum use of the pupil's present knowledge.

A brief definition or discussion, being followed immediately by a set of numerical exercises sufficient to fix the point in mind and give him practice in attacking problems, seems to the reviewer to be a most excellent thing.

The book has certainly the following desirable features, quoting from the preface:—

"1. It contains an adequate amount of information in an immediately usable form."

"2. It applies the information contained to real things."

"3. It drills the student in solving problems, giving him clear-cut conceptions of the conditions of the problems."

"4. It presents only those facts and principles that a technical student needs to know and know well."

It is an adequate treatment of a few fundamental ideas, rather than a general treatment of many.

It affords a sure foundation on which to build advanced work, and at the same time is a well rounded course for the man who will go no higher in his study.

Only simple algebra and arithmetic are required.

In reading this book one is impressed with the simple language and clear analogies used.

Numerous diagrams appear which are remarkably clear.

Principles are constantly referred to practice and one notes that the cuts are of modern machines.

The tables of analogies are well arranged and exceedingly helpful.

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One notes with pleasure that many of the problems are such as might arise in the shop in actual practice.

Free use is made of the concept of magnetic lines of force.

The magnetic diagram of the fields of the motor, showing why it rotates, is excellent. In fact, the whole chapter on motors can hardly be improved, for the purposes of this book.

The discussion of three wire systems is good.

The matter of inductance, always a difficult one to teach, is well presented, especially the self-inductance of a circuit.

One finds grouped under the head of "Electrochemistry" our old friend, the voltaic cell, the storage battery, the new Edison cell and electroplating.

Chemical action is explained on the basis of the ionic theory, although no mention is made of ions, as such.

The presentation, however, is perfectly clear.

The book has also chapters dealing with Illumination, Measuring Instruments, Alternating Currents. Summaries at the ends of chapters make helpful reviews.

For Physics teachers the chief value of the book lies in its accurate definitions, clean-cut explanations of differences in terms and apt comparisons of quantities.

It is a good book with which to brush up one's knowledge of electrical engineering elements.

One can find little to which he may take exception, but perhaps some of us would not agree with the author in making no distinction between the plus plate and the plus pole of a voltaic cell.

In the electrolytic cell, the negative plate is the one by which the current leaves the electrolyte, but in the voltaic cell, if one follows the nomenclature of the author, the current leaves by the plus plate.

Again, on page 421, the author says that the driving torque of a recording wattmeter and the retarding torque on its armature are always equal, so that some students might be puzzled to know how the armature could rotate under this condition.

The fact that a careful perusal of the 500 odd pages of this book reveals so few statements to which one could make any pretence of objecting, it seems to me shows clearly how well the author has performed his task.

"ESSENTIALS OF ELECTRICITY."

By W. H. Timbie. Published by John Wiley and Sons, New York, 1913.

This is a little book of 260 pages, approximately, and is designed especially for wiremen and workmen in the electrical industries.

It is more applied in character than the author's larger book entitled "Elements of Electricity," but contains the more important facts and principles, with irrelevant matter left out.

It aims to explain the underlying facts and principles of good

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electrical practice, but does not attempt to describe actual installation work, as this is best learned by actual experience "on the job."

Full use is made of the student's own experience in shop or laboratory.

The following topics have a chapter apiece: Ohm's Law, Simple Circuits, Series and Parallel Circuits, Power, Wiring Systems, Generators and Motors, Locating Electrical Troubles, Batteries, Wiring Diagrams. There is also a useful appendix of electrical constants.

It is easy for one who has taught electrical trade school classes to become enthusiastic over this little work.

The directness of the author's presentation, his happy faculty of illustrating his points by familiar things and his simple language are important elements that make for the success of this book.

It would be well for every Physics teacher to read this book, if only to make him familiar with the applied side of electricity.

Problems are numerous, but are not difficult arithmetically, and, besides, are preceded by model examples showing every step.

Algebraic forms are omitted, the laws being written out, using the names of the units; for example, instead of $C = E/R$, we find "Current in amperes equals volts divided by ohms."

This is wise, as shop men especially will shy at an algebraic expression of a law that they will handle perfectly well when written out.

One particularly clear piece of work is the explanation of the circular mil unit of cross sectional area.

Line cuts and half tones are well executed.

Modern apparatus only is shown.

One notes in the chapter on dynamos an excellent treatment of the commutating pole so much used to prevent brush sparking.

The tabulation of dynamo troubles and their remedies is in convenient form.

The tests are well presented and are practical shop methods.

The wiring diagrams include the familiar bells, gas lights, annunciators, and in addition the circuits of a gas engine ignition system, block signal and even the track switch of the street railway.

The value of the book for Physics teachers, it would seem, lies in the answers it will provide for those troublesome "questions right out of the shop" that some pupils bring into the class room.

On recommendation of the Executive Committee, the following were unanimously elected to membership:—

ACTIVE.

Samuel Beeber, South High School, Worcester, Mass.
George H. Boyden, South High School, Worcester, Mass.
John E. Dowd, Classical High School, Worcester, Mass.
Richard O. Dummer, Hope Street High School, Providence, R. I.
Matthew R. McCann, English High School, Worcester, Mass.

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ASSOCIATE.

Ernest H. Griswold, High School, Weston, Mass.
William J. Nutter, High School, East Bridgewater, Mass.
Miner H. Paddock, Technical High School, Providence, R. I.
Newell D. Parker, Standard Scientific Company, New York, N. Y.

Professor Ira N. Hollis of Harvard University then gave a talk on

"THE SCREW PROPELLER."

He said in part as follows:—

Most people have a total inconception of the function of the propeller. Any case of the overcoming of a resistance implies a reaction in the opposite direction, and the centre of gravity of the universe is going to move at the same rate of speed continuously unless affected by something outside. The propeller is for the purpose of making some part of that system move in one direction, while another part, large or small, moves in an opposite direction. This idea is not well understood by those not educated in physics. Moreover, the design and function of propellers is not well understood by many physics teachers. In connection with this, mention was made of an invention by a man who divided his ship model into two parts; the forward half like any other ship, but the after part built like the rattle of a rattlesnake, in sections. He got his idea from watching a fish swim, and called it a fish tail propeller. By flipping the after part from side to side he expected to make his ship go forward. His idea amounted only to a beautiful model.

There have been many types of propellers. The screw type may be said to consist in part of a helicoidal surface developed by the motion of a straight or crooked line about an axis at a uniform or non-uniform rate. In general, however, it is a surface developed by a straight line at *right* angles with the axis, moving at a *uniform* rate. The pitch is measured, just as in any screw, by the distance between two successive threads along a line parallel with the axis. The propeller, however, moves in a yielding, not a fixed medium, like the nut of an ordinary screw. Furthermore, as used, it consists of a helicoidal surface of variable, increasing pitch. As a result of the yielding medium in which it moves, the screw propeller does not, like the ordinary screw, advance by the amount of its pitch in one revolution, but less. This difference is called the *slip of the propeller*. It varies from 5 to 75% of the pitch. Much energy is lost by this slip, which is made less by increasing the area of the surface of the propeller. Increasing this area, however, increases the surface friction, which is again a cause of great loss of energy. Propellers must, therefore, be designed of such an area and pitch as to get the maximum efficiency. The slip is usually too big. The larger the diameter of the propeller for a given boat the less it becomes.

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The problem here is to fix the diameter; and thousands of dollars had to be expended to find the right diameter when the turbine ship was brought out, as here enormous speed in revolutions per minute is essential with the turbine engine. The propellers of the turbine ships have a much smaller diameter than those of other types.

Many slides were thrown on the screen to show the development of the propeller during the past 200 years. At first the continuous surface was used, and it was only after many years that the breaking up of the surface into sections was brought out. The pitch was uniform and at right angles with the axis. The idea at first was that the more surface exposed by several blades the greater the effect. It was only by accident that it was found that it was possible to get greater efficiency by using fewer blades, when on a four-blade propeller two blades were removed and it was found that the same speed of the ship could be secured on less horsepower. The scientific development of the propeller dates from the time of this discovery.

Owing to the centrifugal motion throwing off water laterally, it was believed that much energy was wasted, as this did not help the propeller forward. To prevent this the periphery of the blades was bent in scoop form so as to send the water off backwards. Experience has shown, however, that the loss from the throwing off of the water laterally is not a thing to be fought, as the frictional resistance increases too much when the blade is bent. The best effect is secured by having the blade strike the water gently and throw it off rapidly at the periphery. The expanding pitch does this, as the periphery has a speed of five to six times that of the hub. The peripheral friction should be eliminated as far as possible. This is brought about in modern propellers by cutting off a little from the edge of the blade near the hub and much at the end. The greatest surface exposed is around the centre of gravity of the blade. In appearance a blade so treated is elliptical as looked at in the direction of the shaft for the regular type of engine, and more nearly circular and shorter for the high speed turbine engine propellers. Friction at the hub is diminished by making blades and hub of one part, finished smooth. At the periphery and edges of the blade it is decreased by having as sharp a cutting surface as possible, bronzed to prevent its wearing away.

In the case of high speed turbine propellers the cavitation behind the blades produced by the rapid revolution is counteracted to a considerable extent by having two propellers, one some distance behind the other on the same shaft.

The whole subject of propeller design is not yet on a scientific basis for all cases, but it has been developed well enough for known cases. There is no mathematical basis upon which designs can be made.

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Then followed an address by Thomas A. Watson on the subject of

"THE BEGINNINGS OF THE TELEPHONE."

Mr. Watson, who is a native of Salem, spoke of his leaving Salem High School at the age of thirteen and entering an electrical machine shop in Boston as an apprentice, that of Charles Williams, one of the largest at that time in the country. He gave an interesting picture of such a shop in the early '70s. They were all small and crude, but they were the forerunners of the great electrical works of the present day, which employs many thousands of men. He described his work at Williams' and spoke of the constant stream of wild-eyed inventors, most of them ignorant and visionary, who came to the shop to get their crude ideas worked out.

Young Watson was a favorite with such men as he did much of their work. But not all the inventors who came to the shop were of this type. Moses G. Farmer, the leading practical electrician of that day, had all his work done there. Watson did most of it, learning from Farmer all there was to know about the science of electricity at that date.

Watson was making some torpedo exploding apparatus for Farmer in the winter of 1873-4 when Alexander Graham Bell came to Williams' shop to have a new form of the Morse telegraph worked out. This work was assigned to Watson. It was an invention of Bell's, which he called the harmonic telegraph, by which he expected to send six or more Morse telegraph messages over a single wire at the same time without interfering with one another.

Watson helped Bell experiment upon this for months, without perfecting it, but in the course of these experiments something happened that led to the discovery of the speaking telephone, a thing of which Bell had dreamed for years but which he had never put into practical shape. He had, however, worked it out theoretically to such completion that he was like a charged mine that needed only a spark to set it off. That spark came to him one day in the shape of a deranged piece of his telegraph apparatus which accidentally produced an effect that showed Bell instantly that his theoretical conception of a speaking telephone could be realized in a simple workable form at once.

The very day of this discovery Bell gave Watson directions for making the first telephone. Watson carried out Bell's orders, and so had the honor of constructing the first telephone ever made. To test this, Watson also ran the first telephone line ever constructed. The tests of his first telephone convinced Bell that he was on the right track.

Experiments on the harmonic telegraph were abandoned and Bell and Watson devoted themselves to the telephone. Bell's financial backers made a contract with Watson by which he gave his entire time to the experimenting, recompensing him by assigning him a

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share of all Bell's patents. During the next year a multitude of experiments were made on the telephone, perfecting it sufficiently to allow of its Exhibition at the Centennial at Philadelphia in the summer of 1876, and soon after to the point where it was ready for practical use.

The lecturer spoke dramatically of the first test they made of the telephone on an outdoor line two miles long, which was such a success that the *Boston Advertiser* the next day published in parallel columns the conversation Bell and Watson carried on, the first conversation ever made over a practical telegraph line. He then spoke of the array of great scientists who made pilgrimages to Bell's laboratory to see and test the new wonder. The first profit that ever came to Bell form the telephone was derived from a lecture course on the subject that Bell gave in the spring and summer of 1877.

The first lecture was given at Salem to the Essex Institute; then followed others, in Providence, Boston, New York, and all the principal cities of New England. Bell would always arrange to have the hall where he lectured connected by telegraph wire with some distant point, where Watson was stationed to transmit to the hall the electrical effects needed to illustrate Bell's talk. These effects were musical notes sent by circuit breakers of various pitches, music from an electric organ, cornet playing, but principally, shouts and songs by Watson, who had developed a voice like a steam calliope by much shouting through the telephone.

Mr. Watson told some amusing incidents connected with these lectures and read a poem which appeared in the *Lawrence American*, May 29, 1877, entitled "Waiting for Watson," which commemorated an occasion when the wires did not work well and Watson failed to make Bell's audience hear a sound. These lectures were so profitable that Bell married and went to England on his bridal tour and to start the telephone business there. Watson started the manufacture of telephones to supply the great demand that had been stimulated by the lectures and found himself overwhelmed by the demands, also for many kinds of apparatus needed for use in connection with the telephones, such as call bells, switchboards, etc., none of which were in existence then and had to be devised in a hurry to meet the needs of the new business.

The lecturer paid a feeling tribute to the memory of Thomas Sanders, the principal financial backer of the company and its first treasurer, to whose pluck and optimism all the original owners of the business owed much of their reward. Watson's strenuous work during this busy two years came near breaking down his health, for which reason he resigned his connection with the telephone business in 1881 and went abroad, never resuming the work, as he preferred to experiment on new inventions. Mr. Watson closed by saying that although he was proud that he had the opportunity of doing so much of the early work on the telephone, his greatest pride was that he

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was one of the great army of telephone men who have brought to such a state of perfection the present stupendous telephone business.

Before proceeding to the election of officers for the year 1913-14, Mr. Griswold announced that the Executive Committee recommended that hereafter the sum of fifty dollars be allowed the Secretary as a salary, to be spent by him as he sees fit. It was unanimously voted that such an amount be allowed.

The following officers were then elected:—

President, Fred H. Cowan, Girl's Latin School, Boston, Mass.

Vice-President, William H. Timbie, Wentworth Institute, Boston, Mass.

Secretary, Alfred M. Butler, High School of Practical Arts, Boston, Mass.

Treasurer, Percy S. Brayton, Medford High School, Medford, Mass.

Executive Committee:—

Clarence M. Hall, Springfield High School.

Fred R. Miller, English High School, Boston.

Clifford S. Griswold, Groton School, Groton.

Many then took advantage of the opportunity of taking lunch at the restaurant in the Boston Art Museum.

AFTERNOON SESSION.

The new President, Mr. Cowan, opened the afternoon session by introducing Mr. William H. Timbie of Wentworth Institute, who spoke on:—

APPLIED SCIENCES FOR PLUMBERS.

In order that it may be clear why courses in Applied Sciences are being developed at Wentworth Institute in the particular way which I am going to describe, I have introduced a few illustrations to show the type of student and the practical nature of his work here.

The first illustration is of the class work in the plumbing shop; the second, shows the Foundrymen at work on the molding floor; the third gives an idea of the practical work done by the class in Carpentry and Building.

The object of our Applied Science courses for these men is to develop brains, the *power* to reason, and the *habit* of reasoning, particularly about every-day matters. This I take it should be the function of all science courses, whatever they are called, in secondary schools. This should be the criterion by which a Physics course should be judged; not how much ground has been covered, how much knowledge, or how many facts have been crammed into

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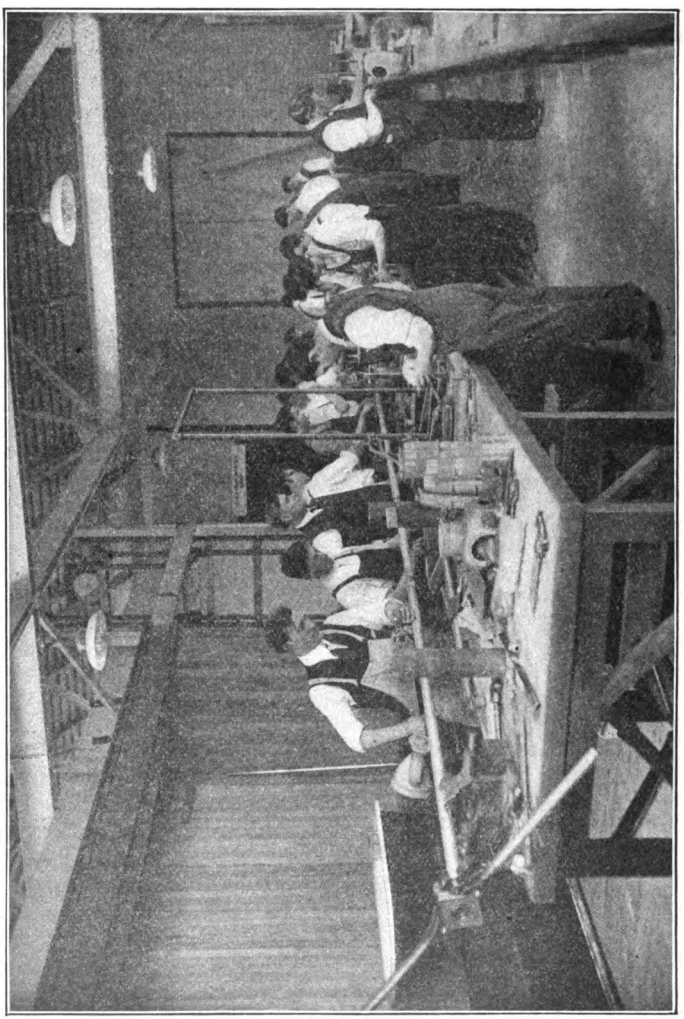

The Class in Plumbing

Fig. 1.

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the students' heads, but to what extent he has acquired a power and habit of productive thinking. The Physics course which best fulfills this one function, is the best course.

To succeed in teaching Physics, it seems to me, as in the automobile business, it is necessary, 1st, to apply correct principles, and 2nd, to continually improve courses so as to put out a 1913 model in the year 1912-13. When you go to an auto show, you want to see the latest model, and so when you come here, I assume you want to see our 1913 models. Now I'm not going to show our entries in all classes, but have picked out one, the Applied Science of Plumbing, which may be used as a type. I want to tell you however, that we are in the market in seven other classes, and have distinct science courses worked out for each,—all of them more complete than the one which I am going to detail. This is a sort of science course in the raw, or in the making, so to speak, and the processes show up a little clearer for that reason.

When I tell a fellow teacher who asks me about the work at Wentworth, that I am teaching science to plumbers, they always smile, most of them say they are sorry for me, and all of them look it. I suppose they think the plumbers are "the guys to put the sigh in science." But frankly, I've had the time of my life for two years with the classes of plumbers, and for this reason, and because it presented some unique problems, I am going to tell you a little of my experience with this one course.

I'm going to try to refute the supposition that there isn't much ground to be covered in the science of plumbing. If you'd been right up against it as many times as I have during the last two years to explain the facts which were brought out in the laboratory, or to make the computations required in the classroom, you'd appreciate that, though we've only scratched the surface, it is isn't any boy's job we're undertaking. A plumber at the present time stands in about the position of the barber of medieval times, who had to be a dentist and a physician as well as a tonsorial artist. The science relating to his trade touches about every department of physics.

In this class we started in with water pressure, static. We brought out the remarkable fact that the pressure of water at a given point in a system doesn't depend at all on how *much* water we have above that point, but on how *high* the water stands in the system above that point. The schemes we use are almost childlike. With a pressure gauge, Bourbon type, the pressure is measured in a pipe which leads to a tank 15 feet above.

Then a small pipe of the same height is filled with water to the same level, and of course the gauge reads the same pressure, tho only a few pounds of water are above it.

Using the same tank, pipes and gauges, the relation of height in feet to pressure in pounds per sq. in. is obtained. All the student

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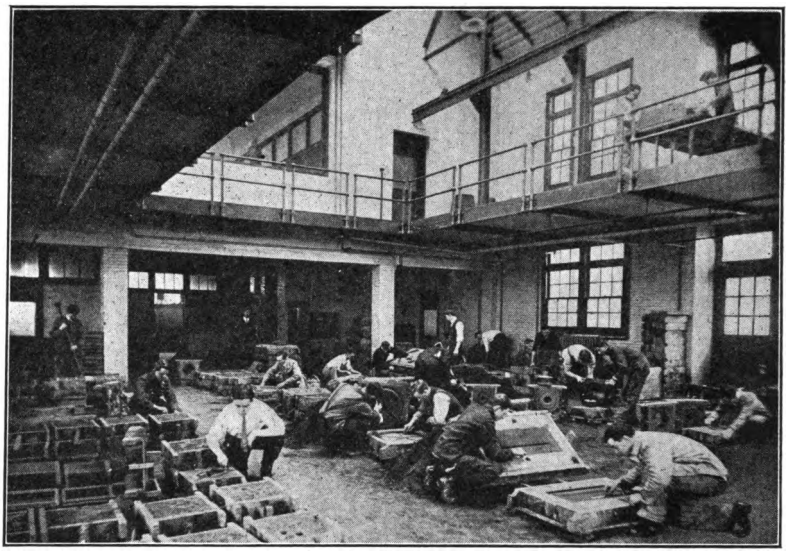

FIG. 2.

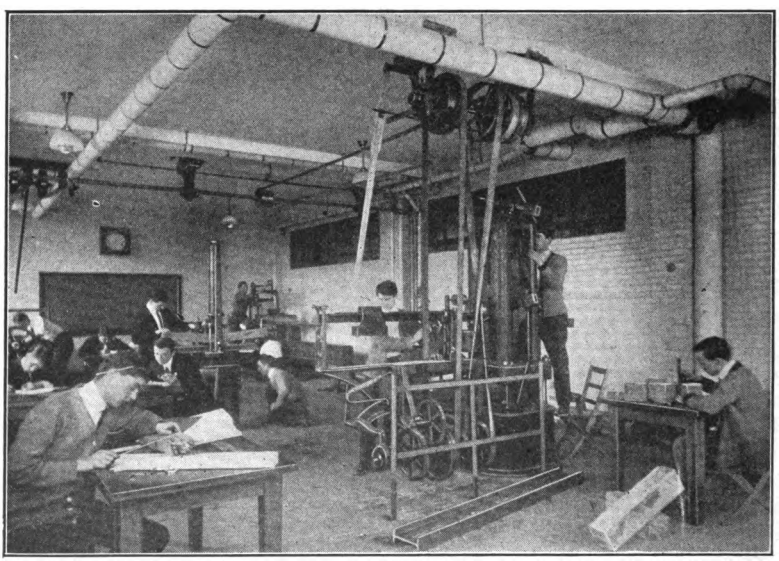

FIG. 4.

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does is to measure the height of water above the guage, and read the gauge, and do a little example in long division. He now can take a gauge thruout the building and measure the pressure on the several floors and compute the difference in level between the floors and check it by measurement; also compute the height of a tank which would produce the same pressure.

Next we put the usual Pascal vases in his hands and let him actually measure the water pressure on the bottom of each vase of different shape but with the same base area, and same head.

By means of Knott's "Seven-in-one" apparatus, the fact that the total pressure on a surface equals the area of the surface times the pressure per sq. in. is seen. He can now compute the pressure on the bottom of the tank, on the inside surface of pipes, etc.

A pressure regulator is then given him which depends for its action upon the difference in area of two pistons, very much like the hydraulic press. We have 5 or 6 of different makes in the laboratory. In accordance with our theory of teaching, we have the pupil fasten a regulator to the water supply system, study its action, and learn how to set it. Then when his curiosity and interest are sufficiently aroused, he is given a cut-away model from which he studies the construction and principle of operation, and works out problems based on this piece of apparatus.

The weight of a cubic foot of water is determined by weighing that quantity in a small tank. He is led back to the seven-in-one piece, which he now uses as a hydrostatic press, to impress on his mind again that it is not the weight of the water which produces the pressure.

The class room now begins to get in some good work with problems, especially on the strength of different sized pipes; of different materials, lead, iron, steel, brass; welded and seamless. This requires some pretty figuring and some neat demonstrations as well as laboratory work in bursting different size pipes of these materials. Then the effect of threads of different depths is tested and computed.

The comparative strength of wiped joints with the original pipe is taken up. Here is where we work in a little course in strength of materials for the plumbers and they are totally unconscious of it under this name for it. We just make use of his natural interest in these things when his interest is the highest. Fig. 4 shows the class at work in the testing laboratory, finding out about the properties of different materials. No set course is laid out thru which the men all advance in company front. Even our well endowed Institute couldn't afford that expense, assuming we considered it desirable. And I want to say as emphatically as I can that I consider the company front business absolutely wrong in principle. The idea that all the class have to do the same thing at the same time is one of the greatest drawbacks to real achievement in most physics teaching. The main thing is to keep the boy inter-

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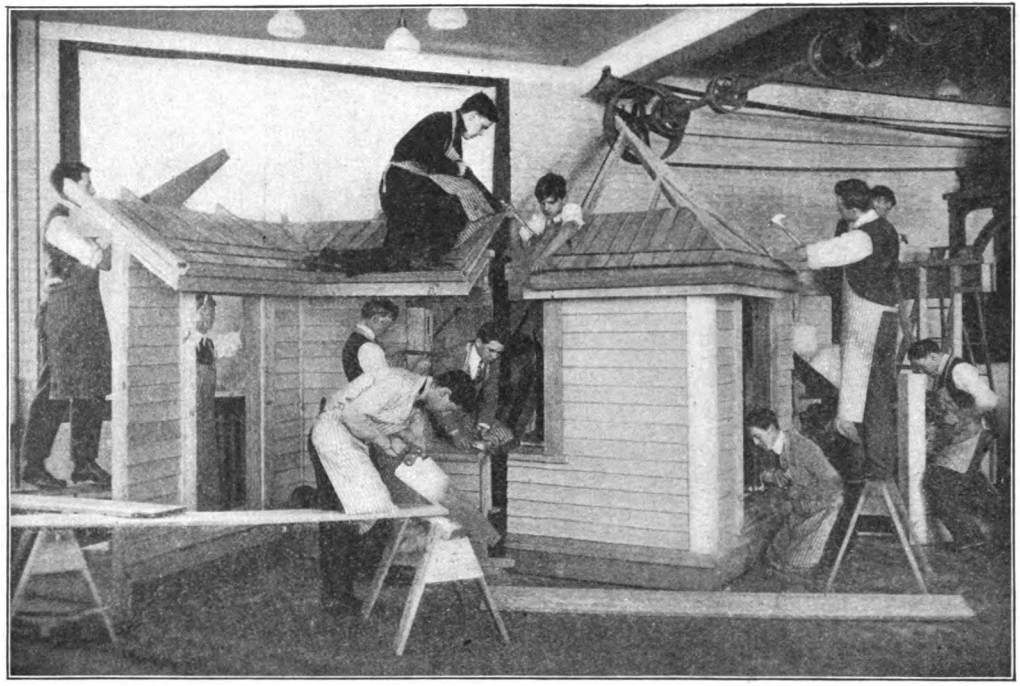

Fig. 3.

Class in Carpentry and Building

A great variety of practical problems similar to those shown in the photograph are worked out by the Class in Carpentry and Building.

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ested. Interest is the big point that we instructors should keep before us. A thing, in which a boy is interested, he will work on, even to the neglect of all other things and to the detriment of his health. Witness the "wireless" craze.

The next point is the great truth which we have discovered years ago in this work, that a teacher really can teach a pupil mighty little. Some of us go so far as to say he can teach nothing at all. Experience, information, self-control, and all other desirable things must be *learned* by the pupil, not *taught* by the teacher. The less the teacher enters into it, the better, because it means the more the pupil is doing and learning.

If we Physics teachers really want to learn how to teach physics and teach it correctly, let us learn the methods used by Madame Montessori in conducting her "House of Childhood." Here all is interest; learning thru *doing* and *handling* the things in which the three-year-olds are interested. You'll have to admit, that, measure the results any way you wish, she is miles ahead of our kindergartens. And, fellow teachers, the same principles of education applied to Physics teaching will put a course conducted in this way as far ahead of our present Physics courses as her school is ahead of the kindergartens.

But that's aside from the subject in hand, altho it explains the pedagogy of several pieces of laboratory work which we keep going thruout the year, regardless of sequence, in order to conduct classes without this company front idea.

We obtained a couple of hundred fittings of different sizes and materials, numbered them and put an assortment of about 50 in a box. These we hand out, a box at a time, to a student. He is to list the name, use, size and approximate price of each piece. This looks easy, but there has been more rivalry and interest taken in this work than in any other part of the course unless it is in estimating the weight of one-hundred such fittings, and the number which it would take to weigh 100 pounds. Furthermore, several of last year's men have come back with the report that this was the one thing which helped them most on the job.

Another bit of work which we keep running thruout the year is the study and use of the different makes of die stocks for threading pipes. Nine manufacturers have installed for our use as many different kinds, and every boy studies the action and learns to use each during his course. Right in this one exercise is a neat little study of machines, ranging from the simplest to some that we instructors worked hours over in order to learn all that could be done with them. Methods of making the thread taper, of cutting threads of depth greater and less than the standard. Samples thus cut are afterwards tested for strength, and the reasons discussed as to why standard threads have the greatest strength,—a further study in strength of materials.

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To the list of this sort of laboratory work I might add the study, setting and operation of water meters, gas meters, standard smoke tests for breaks, construction work, etc. We do not hesitate to set the men on the most exacting type of construction work, having one man act as sub-foreman under an instructor. All of these belong to no set sequence of experiments but can be put anywhere in the course and afford an opportunity for keeping the students each on a different job from the others. And all are *interest* makers.

But, to return to the so-called regular course. The student now having some experience and a little knowledge of static water pressure, takes up atmospheric pressure, which opens up the wide field of syphons. The plumber abhors a vacuum twice as much as Nature does, and the apparently infinite number of schemes which he uses to let air into the waste pipes, traps, hot water boilers, etc., afford endless laboratory tests and classroom problems in air and water pressure.

Since the pressure and vacuum gauges which plumbers use all have to be tested against a column of mercury, each student constructs his own mercury barometer, and learns how the atmospheric pressure causes it to register. He reduces the reading to pounds per sq. in. and by the following practical application becomes very familiar with the method of stating pressure and vacuum in inches of mercury.

The standard pressure which a finished job of gas piping must stand is 5 inches of mercury. Model piping systems are tested by means of a mercury manometer, leaks discovered and remedied. Then sections of gas piping of the Institute are similarly tested. Here again the interest which the student has in the standard test and method of locating leaks causes him to master the idea of the mercury barometer and manometer. By means of a small water manometer he tests the gas pressure thruout the building. These tests make him familiar with the combination of water and gas pressure in a perfectly natural way, which is also mighty interesting and useful to him.

He is now ready to experiment with syphons of which we have a large number made up out of iron pipes. He tries the effect on the flow of varying the lengths of the legs. Syphons with equal legs but of different bores are then tested, and then with different lifts. When a student thinks he knows all about syphons, he is put on a boiler, the regular kitchen boiler, and a syphon is arranged which will apparently empty it, but no air is admitted to the boiler. Here under actual working conditions he learns that air pressure is necessary to the working of a syphon, especially when he finds how quickly the boiler will syphon when the air is let in. Likewise the mystery of the little hole near the top of the cold water pipe becomes clear to him.

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He now investigates the case of a trap which is connected to the stack in such a way that the waste pipe forms a long leg of a syphon, and so syphons the trap every time the trap is used. He sees that this syphon action can be stopped in two ways; either by lessening the slope of the waste pipe so that it enters the stack at about the same level as the water seal in the trap, or by venting the trap, which admits air to the top of the syphon and thus destroys its action. A complete study in the different systems of venting is now taken up and the city law discussed.

When we get into the new building, I am going to build a syphon which can be adjusted to about 35ft. lift and prove still further that the air pressure is not only *necessary* but is also *limited.* A pump with the same adjustable lift will also be installed.

While on the study of the gases, the men verify Boyle's Law on an instrument from which the pressures and the volumes can be read directly.

A closed end manometer is then used to check the guages and to read the water pressures in different parts of the building.

The following little group of tests brings out well the surprisingly large number and widely scattered applications in which the same principle may lie hidden in some every day appliances.

Take the case of the aspirator, or the mercury pump. To-day a plumber is called in to install a vacuum cleaning outfit which is nothing more or less than our old friend the aspirator. So we run a test on that appliance. The student learns how the air gets entangled in the rapidly moving water and is carried with the water to the sewer. Next he tests a jet pump which is commonly used in his business to drain cellars. He finds the same principle applies.

Being set to regulate the flame of a gas heater he finds the same principle of the friction of a moving fluid on another imparting a motion to the stationary fluid, only here the fluids are gas and air. As we have on hand 10 or 12 gas heaters, the students get all the particulars necessary to learn how to regulate the flow and mixture of gas and air.

Now when the young man comes to study that bane of the plumber's trade, the syphoning of the lower traps in a system, he has some data to work on and some explanation that really explains. He doesn't have to fall back on that handy but ambiguous "force of suction."

He already knows from the test described above that the upper trap won't syphon if the waste pipe enters the stack at a point above the bottom of the seal. But he finds that the lower one still syphons even tho the level is all right. He soon reasons that it is merely another application of the friction of the air on the moving water causing the air in the upper part of the trap to be carried away. This is prevented by means of a vent. This test is performed first on a set of glass traps and a glass stack so

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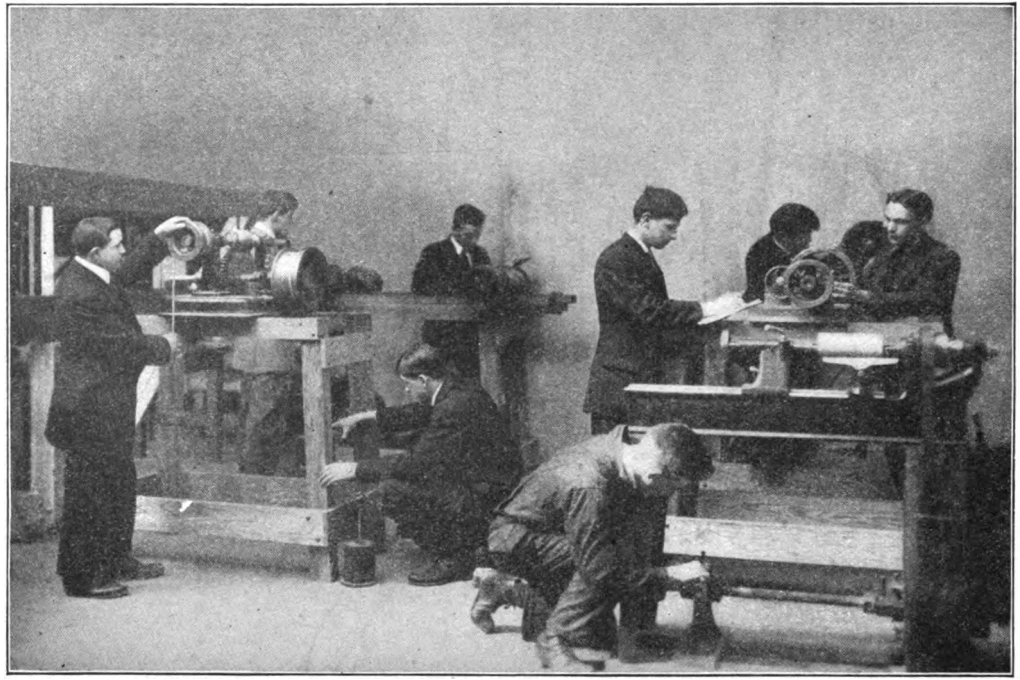

Fig. 5.

Students in Laboratory of Practical Mechanics

Testing back gears, change gears, speed cones, worm and worm-wheel, and similar problems.

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that the action can be seen. Then real traps are tested in a piece of apparatus which you can see in the next room. And some mighty interesting things come out which there isn't time to take up here. I brought these up to show how this one principle was illustrated in four widely separated ways, and all the ways were on live apparatus.

Having gotten the men to study moving water, we now take the other phenomena connected with it, as for instance, the loss of static-head, due to a gain in velocity-head, and the use of some of the static-head as friction-head to overcome the friction in pipes. For the study of this we have rigged up the apparatus which I threw on the screen at the beginning of the hour. We have found out that a 90° bend causes about 5 times the loss of pressure head that a 45° does. We have also investigated the effect on the flow of curves and of valves, and of the different size pipes under the same head. By means of the pump we find out how much extra pressure is needed for each bend in order to force the same current thru it as thru a straight pipe.

We have set up a pipe with glass gauges attached to it at different points along it which show the falling off of the pressure all along the pipe at different rates of flow. This also is used as an analogy to show the fall of potential along an electric wire carrying a current.

Archimedes' principle is studied and mastered by means of ball-cocks, ball valves, etc., operating in an actual flush tank. The principle is then tested in large blocks of concrete, and metal, and wood, in large tanks of water.

The effect of a water hammer is shown as follows. With the valve to air chamber closed, the water is allowed to flow and then is suddenly shut off, and the sudden rise of pressure is noted on a gauge. Then the valve to air chamber is opened and the effect of suddenly stopping the water flow is again noted.

The different methods of locating air chambers in actual installations is carefully taken up and several of those in place in the Institute are tested as to their efficacy.

An actual water ram has been installed by the students and its action studied and tested by means of a gauge set on top of the air chamber. Its efficiency as a machine is very easily tested, so it makes a good introductory experiment to the study of work, power and energy.

The Gould's triplex pump makes the next short step, followed immediately by the operation of an electric motor, from which they learn that *amperes* corresponds to the flow of water and *volts* to the pressure of the water.

Fig. 5 shows a group of students learning the effects of the different means of power transmission, belts, spur gears, worms, chains, etc.

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A Ridy-Ericsson hot-air engine shows that heat can be transformed directly into foot-pounds of work, since the simple burning of so much gas, pumps so many pounds of water so high.

So without the student being aware of any transition across the conventional line which separates the subjects of mechanics and heat, he has stepped into the midst of the subject of heat, thru the easy gateway of energy. In studying the hot-air engine, he soon learns that it is the pressure and expansion of the hot air that pushes the piston up, and the pressure of the atmosphere which pushes it down as the enclosed air is suddenly cooled, thus losing its pressure.

From the expansion of air he goes to the expansion of water, using one of the regular kitchen boilers and heaters with which he is familiar for that purpose. He closes the valve, which shuts off the hot water, and also the valve shutting off the cold water which is a stop and waste with the waste placed next the boiler. As the water now heats up it expands and flows out thru the waste valve. The expansion is thus very real to him. Then we wish to show him the force of this expansion, so he puts the gauge and a relief valve set at 100 pounds on the boiler. A shut-off valve is now put on in the place of the stop and waste valve, for this experiment only, since we teach that it is bad plumbing practise to set up any system which isn't fool-proof. All valves are closed, making an absolutely closed system. The relief valve soon begins to discharge and the pressure gauge indicates how quickly a higher pressure is gotten up. Such tests as these not only teach the facts of physics, but they teach them in connection with the application of them which is most likely to be met by the student in actual practise. They also teach these facts in a way which makes it hard to forget them and their application. Later when I get my concrete floor and don't mind the flood which is necessary, I'm going to actually burst a boiler or two in order to still further impress the force of this expansion on their minds.

For the expansion of solids, I have a 50 ft. iron pipe rigged up thru which I can force steam. My steamer works so well that I want you to notice it when you inspect the laboratory. It consists of an ordinary heater connected to a pail of water so arranged that the upper part of the coil is above the water level and thus free to make steam, which it surely does in tremendous quantities in less than two minutes after lighting the gas.

But besides the force which heated water can exert there is the other principle of its becoming lighter as it is heated. And right here is where we touch about the livest wire in all plumbing,—the circulation in hot water supply and heating systems. Outside of the proper venting of traps, there is more discussion going on about why some hot water systems work and why some don't, than in any other branch of the trade.

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So we are rigging up about 10 or 12 heaters to 4 boilers on which we are doing all sorts of stunts. But first I want to tell you that I find most of the trouble centers in the firm belief which all people seem to have that "hot water rises" under every and all conditions. Now that I have gotten that idea out of the plumbers' heads, we are making a little progress on the principle of the heater and boiler. One test which helped more than any other to clear up this ambiguous statement, was the following.

Two 12 ft. wrought iron pipes were set up. Then about 3 ft. of glass tubing was set in the end of each. The two pipes were joined together at the bottom, but the connection from one pipe to the other was closed by a valve. The pipes were filled, one with cold and other with hot and the water regulated to the same level as determined by the glass tubes at the top. The readings were taken of gauges, which were located one at the base of the hot water pipe, the other at the base of the cold water pipe. It was found that the cold water column, altho of exactly the same length, produced about a quarter of a pound more pressure than the hot water column. The valve between the two pipes was now opened and the cold water immediately forced the hot water up about six inches. The student now sees clearly that hot water doesn't rise, but is lighter than cold water, and is forced up by the cold water.

Very careful and exhaustive tests are then made on the circulation of hot water in supply and heating systems, and the different causes of success and failure are brought out and discussed on a scientific basis, and not by "rule of thumb."

For this purpose we have three boilers equipped with thermometers which read the temperature at several points in the boiler. Others show the temperature of the water as it enters and leaves the boiler.

Efficiency tests are also made on a dozen or so makes of gas heaters. In this way the plumber becomes familiar with British Thermal Units and the meaning of heat energy, quality of gas, etc.

Specific heat is used in testing the specific heat of fire-clay and then using the clay to find the temperature of a gas heater for the soldering irons..

The latent head of lead, tin and solder is studied and the melting points determined by tests in the laboratory. The building laws on ventilation are taken up and the laws for the flow of air and for the heat required to heat a building are studied.

Pipes are artificially frozen and caused to burst, and the force which the ice must have exerted is calculated. Frozen pipes are then thawed out by electricity in order to get the student familiar with this method. In this connection and with the electric motor, electric thermostat, and electric lamps, the plumber gets a good grounding in the principles of electricity. He wires up lighting systems, in order that he may know something about the value of

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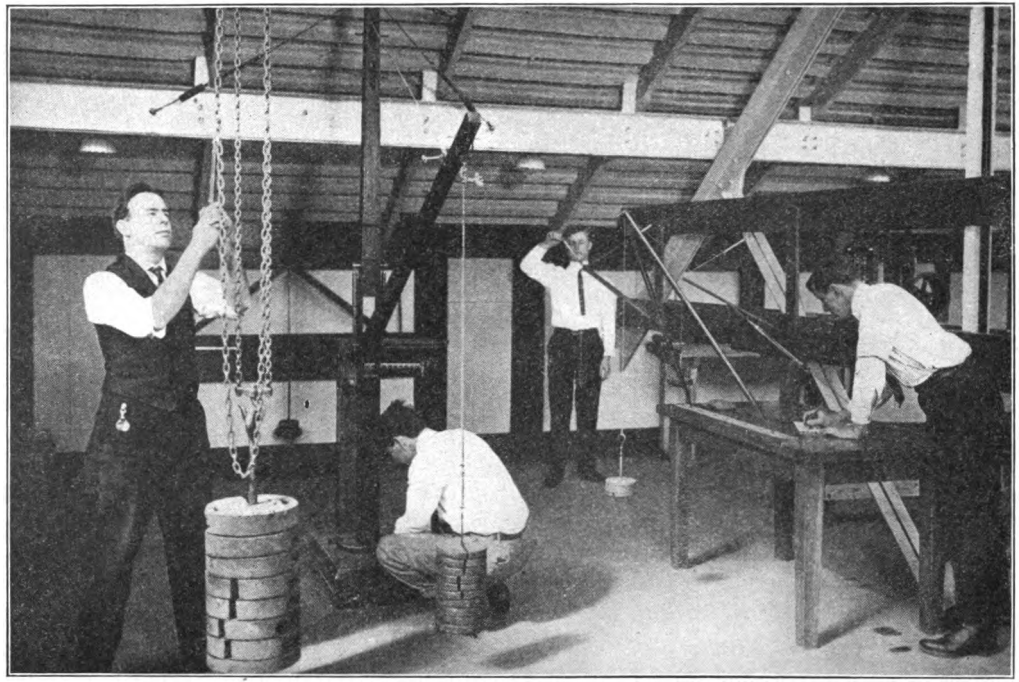

FIG. 6.

Analyzing by Spring Balances the Forces Acting on a Jib Crane

These experiments are typical of much that is done in the Laboratory of Practical Mechanics. They show how the hidden forces acting on a great variety of structures or machines may be separated and made entirely plain.

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insulation, polarity, radiation, etc. He sets up an actual furnace and equips it with a real electric thermostat placed in a box, the temperature of which he can control. In this way the subject of heat and electricity are joined, as they also are in his study of an electric soldering iron, compared with a gas and gasoline iron.

An interest in forces and moments of forces is aroused by a study of pipe dies and stocks of safety valves and quick-opening valves. The principles of resolution and composition of forces are then taken up on apparatus shown in Fig 6. Note that all of it is of a size to command respect, and if not always the actual commercial device, is a large model of it.

Finally a brief course in bacteriology and sanitation is given which covers all the fundamentals which touch the ordinary plumber's every day work, but in which you, as Physics teachers, would probably not be interested.

However, I should like to call attention to the fact that, excepting light and sound, the course outlined includes a fair representation of most of the fundamental principles of physics, taught almost entirely by very numerous and widely separated applications of them.

Science Courses for the seven other trades are being developed in the same way and on the same principles of pedagogy—*interest* and *learning; then experience* in handling and operating.

Following this a tour of the building took place, with close inspection of the applied science, pattern making and machine shops, foundry and power house, in all of which, with the exception of the power house. the apparatus and machines had been installed by the students themselves. This closed a most interesting and instructive meeting, attended by about fifty members.

It was unanimously voted that a hearty vote of thanks be extended to the directors and faculty of Wentworth Institute for their kind and greatly appreciated hospitality; and to the retiring president, Mr. Griswold, for his great interest and untiring efforts during the past two years.

At the annual smoker, held at the City Club on Friday evening, March 28, those present, to the number of twenty-five, spent a very enjoyable and profitable evening listening to the three guests of the evening, Dr. Dyer, Superintendent of Boston Schools; Mr. Meyer Bloomfield, Director of the Vocational Bureau in Boston; and Mr. David Snedden, State Commissioner of Education.

After telling of some of his experiences as a student in college, in his comparison of the scientist and economist, the one with a mind open to changing opinion, the other with an idea of finality in his views, Dr. Dyer said that we cannot say that one method of teaching is right and another wrong. It all depends upon the object sought

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and the conditions to be met. The finest asset that any teacher has is himself, and it is this that he should give to his pupils. A teacher should be allowed every freedom of initiative to carry out any pet ideas of educational methods he may have. He should not be a confirmed, conventionalized imitator, but should be constantly open to changing his views with changing conditions.

Mr. Bloomfield said that the majority of children who drop out of school early do so of their own desire, not because of poverty, as is commonly thought. Either there is not pressure enough brought to bear upon them, or conditions are not right to keep them in school. The result is a very great waste because they take up work for which they are not fitted, since they either do not know what positions there are, nor for what they are best suited. They do not realize that the positions that offer them the best wages at the start are the ones that offer little opportunity for bettering themselves. The object of the vocational bureau is not to advise and direct into what sort of work any individual should go, but to set before those concerned what positions are open, what future they offer, and what they require at the start. In this way the great waste of human energy brought about by this misdirection of effort and its accompanying changing from one occupation to another, will undoubtedly be lessened.

Dr. Snedden's talk dealt with the relative educational values of the types of secondary schools of today. He said that all schools must have a definite goal for which to work. The trouble is that today the goals are not clearly defined. That we are under the influence of two sets, one the immediate, as set up by convention (the colleges), in which subjects are taught without any clear, definite reason, and the other, the vocational. The value of the former must be taken too much on faith, while the definiteness of the goal in the latter makes its value seem greater to people in general. There is danger in this in that it tends to make the material side of education the only object, and idealism becomes submerged. There is great difficulty in proving that other lines of study are valuable to pupils, since that value must be taken too much for granted. Furthermore, in many cases the subject is not taken up to a great enough extent to get the best out of it as a part of a liberal education.

The ease with which the objective of the vocational school may be defined is bringing it into keen competition with the high school of liberal education, and unless the objectives of liberal subjects, which are more to be taught by appreciation and absorption, is made more definite than it is, the vocational schools are likely to supersede the other types of secondary schools. The great problem before us, if we wish our liberal subjects to be in demand, is, therefore, to define our object in terms that can be understood and appreciated.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SIXTY-FIFTH MEETING

OF THE

Eastern Association of Physics Teachers

at Simmons College

Saturday, May 24, 1913

Morning Session

9.30 A. M.

Meeting of the Executive Committee.

10.00 A. M.

Business.

Reports of Standing Committees:

On New Apparatus. George A. Cowen, Chairman.

On Magazine Literature. Frederic H. Sawyer, Chairman.

On Current Events in Physics. George W. Day, Chairman.

On New Books. Ralph C. Bean, Chairman.

Election of New Members.

11.00 A. M.

"Should the Course in Secondary School Physics be the Same for Girls as for Boys?"

Mr. J. C. Packard, Brookline High School.
Dr. L. L. Campbell, Simmons College.
Mr. I. H. Upton, Roxbury High School.
Mr. W. G. Whitman, Salem Normal School.

12.00 M.

Inspection of the laboratories and other places of interest at Simmons College.

12.30 P. M.

Lunch.

Afternoon Session

1.30 P. M.

"Personal Impressions of Lord Kelvin by one who was with him in his Laboratory." Mr. John Hamilton, West Roxbury, Mass.

2.00 P. M.

An Illustrated Lecture. "Edison and the Practical Application of Electricity in the Home." La Rue Vredenburgh of the Edison Co., Boston, Mass.

3.00 P. M.

Inspection of Electric Appliances for the home and a demonstration of the same.

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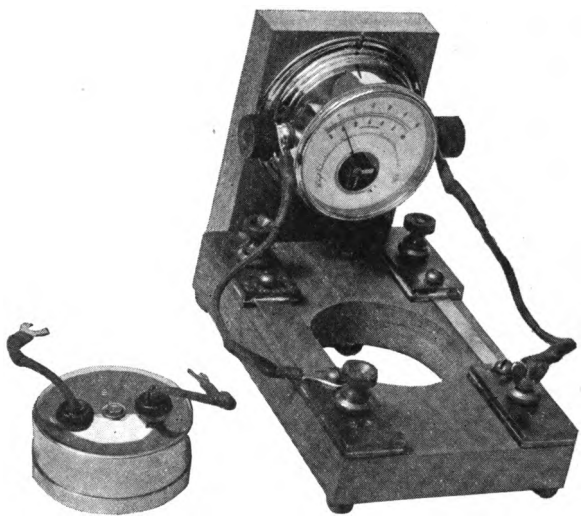
MORNING SESSION.

The meeting was called to order by President Cowan, who called upon George A. Cowen to report for the Apparatus Committee.

Report of Committee on New Apparatus.

Mr. Rice showed a new form of volt-ammeter, devised by Mr. Miller. This (see cut) consisted of apparatus furnished by the Hoyt



Electrical Company, of Penacook, New Hampshire, as follows: Type C 25 millivoltmeter, with scales (*a*) 0-5 volts by 0.1 volts in red, (*b*) 0-10 amperes by 0.2 amperes in black, (*c*) negative reading of 10 scale divisions, *not* zero center. Fittings: (*a*) binding posts at side of meter, (*b*) 5 volt multiplier in case with 4-inch leads, (*c*) 10 ampere shunt with 7-inch leads, (*d*) 20 ampere shunt. These were mounted by Mr. Miller, as shown, with a hole in baseboard to

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receive the multiplier. The meter alone may be connected to a Gilley coil, when electromagnet induction with small bar magnet may be shown. Cost: Meter, $5.25; 5v. multiplier, $.70; 10a. shunt, $.75; 20a. shunt, $.75. Total, $7.45. Mr. Rice suggested that a 5-ampere shunt be substituted for the 10-ampere one.

Mr. Butler showed the Beacon Transformer, Type T, manufactured by the Economy Electric Company of Hyde Park, Mass. This transformer, when connected to the 110 volt alternating lighting circuit, will give 10 different voltages on the secondary, as follows: 4, 6, 8, 10, 12, 14, 18, 20, 26, 30. It has a capacity of 100 watts continuously, and will not burn out when short circuited. Such a transformer can be used in place of dry cells in the study of the electric bell, and in the demonstration of series and multiple connections with minature lamps of low voltage. It will also run electric toys that are series wound, and should be very useful in a laboratory. Cost, $6.00.

Combined with the electrolytic rectifier, manufactured by the same company, a transformer of greater capacity can be used very satisfactorily in place of a motor-generator set in schools where only alternating current is available. The cost of such an outfit ranges between $15 and $75, according to capacity.

The Duplex electric vacuum cleaner, for sale by the New England Lighting Company of Boston, was demonstrated. This lists at $35 and is a very useful and serviceable cleaner at a low price, simple in action and easy to handle; also an excellent one with which to show the principle of vacuum cleaning.

Mr. Cowen showed the Thordarson step-up transformer. The Thordarson transformer is well adapted for high school work for the following reasons: It is a step-up transformer for use on 110 A. C. All its parts are in plain sight, so that the way in which it is constructed can be seen and understood. It is very durable. With care it will last a lifetime. It steps up the voltage to about 20,000, so that it is suitable for all high potential work needed in high schools. It is specially designed to be used for wireless telegraph. When used with a Tesla coil that can be made by any one for a few dollars, it will run the x-ray tube. Geissler tubes light up when brought within a few feet of it. It will give a spark 35 inches long, and will make a beautiful brush display. No end of interesting and spectacular experiments may be demonstrated, depending upon the ingenuity of the operator. The cost to schools is $20. It will do all and more than the high priced induction coils.

Construction of Tesla Coil.—Wooden or paper core, 48 inches long, wound with one layer of No. 24 enameled wire. Diameter of core, 12 inches. Primary, 24 inches in diameter, wound with ten turns of No. 4 bare copper wire. This primary properly insulated is placed about the middle of the secondary. No metal is to be used in the construction of the core or the frame to hold it.

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This transformer can be bought in Boston from the Stuart Howland Company, 137 Federal Street, or it can be bought from the Thordarson Manufacturing Company, Chicago. It is well worth the investigation of every teacher of physics.

Mr. Harrington spoke of an experiment performed with lantern and projection cell, in which was placed a mixture of dilute sodium thiosulphite and dilute hydrochloric acid. A slow precipitation of sulphur caused a gradual absorption of light, beginning with the violet and working into the red. This experiment may be used to show the principle underlying sunset colors.

He also described an experiment to show the reduction of magnetic properties in iron when heated. A thin strip of iron suspended vertically from a delicate spring has an electromagnet just under its lower end. A small flame from a blast lamp is directed horizontally against this lower extremity. The weakening of magnetic properties as a result of the heat, and restoring of them as the iron cools on getting out of the influence of the flame is shown by the up and down motion of the strip.

The electrical, and by calculation from this, the mechanical equivalent of heat may be shown by taking a glass tank with 3 to 4 quarts of water, and placing in it a heating coil. First raise the water to 100° C. quickly. Now cut down the current to a strength that will maintain a temperature of 100° without boiling. In this manner calculate the electrical energy just necessary to counteract heat loss by radiation. Now weigh the water and find how much energy is needed to boil away a certain amount (found by weighing afterwards). The difference between this and the amount needed to allow for radiation gives the exact amount used up in the vaporization. Calculation will give the equivalent.

The report of the Committee on Current Events in Physics, George W. Day, Chairman, follows:

Report of Current Events Committee.

The Moving Picture Industry.

An article and an editorial in *World's Work* for May give some interesting information regarding this subject. More than 20,000 motion picture places in the United States take every day the nickels and dimes of probably 5,000,000 patrons, and it has been estimated that $20,000,000 are invested in the business. The educational influence and importance of this industry is noteworthy. The use of these pictures reveals extensive possibilities to teachers of science and of history. Social reformers and sanitary engineers are finding them powerful aids in presenting to the public their ideas.

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Railroad companies are using them to advertise the features of travelling by their roads. Physicians in medical institutions are showing processes of digestion by motion pictures obtained by use of x-ray photography. Professor Munsterburg has devised a cinematograph nerve test for chauffeurs, pilots and other men in charge of passenger and traffic conveniences. The candidate is placed in a motor car in a dark room before a moving picture screen. A child, in the picture, darts before him; a team dashes directly toward him; a heap of rock suddenly appears. In every case the would-be chauffeur must act immediately; his steadiness or unsteadiness of nerve is plainly revealed. Numerous large cities have introduced the motion picture machines into their public schools,—Chicago, Cleveland, Detroit,—and in others the matter of adoption is being favorably considered.

Progress in Wireless Telegraphy.

The scout cruiser *Salem* was sent as far as Gibraltar early this year to carry on a series of tests in sending and receiving messages by wireless between this vessel and the powerful government station at Arlington, Va. The cruiser sent complete messages to Arlington over a distance of 1300 miles, and was able to receive entire messages in full daylight over 2400 miles, and over a considerably greater distance at night. This government station has been able to read messages from Clifton, Ireland, and to work directly with naval stations at Mare Island near San Francisco, and Guantanamo and Panama.

Time by Wireless.

As an outcome of the Paris International Conference of last year a system of sending out time signals from the greater wireless stations of the world has been evolved, and is to be put into operation after July 1 of this year. All are to transmit Greenwich time, and all the signals are to be of the same Hertzian wave-length. The stations undertaking this transmission are Paris, which will start the first wireless time message at midnight and at ten in the morning; San Fernando, Brazil, at two A. M. and at four P. M.; Arlington, U. S. A., three o'clock and five o'clock P. M.; Manila and Mogadiscio, a station in Italian Somaliland, four o'clock. Timbuctoo will send its message at six A.M. The midday message will come from Norddeich Wilhelmshaven, as well as another at ten P. M.; and Massowah will give the six o'clock P. M. message. San Francisco, last but one in the day, takes eight o'clock. Several hours are thus left to be filled; but Chashi, in Japan, will take one of them, and it is hoped that shortly it will be possible to give and take a day and night signal every hour at any point all over the globe. The greatest value of these signals will be to ships; and doubtless the messages

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will be eventually supplemented by code signals giving definite information regarding the weather at specified stations.—Extract from *Boston Transcript.*

Long Distance Telephony.

The Paris daily papers stated recently that wireless telephone messages were lately sent over a distance of more than 600 miles, from Rome to Tripoli. In these experiments Prof. Vanni of the Military Wireless Institution, near Rome made use of a liquid microphone, together with apparatus of the Moretti type.

Protection of Ocean Liners by an Inner Lining.

The White Star Line and the Hamburg-American Line have profited by the lesson taught by the loss of the Titanic, in having embodied into the construction of two new ocean liners, the *Oceanic* and the *Imperator*, an inner lining. The space between the two metallic "skins" of these vessels is divided into bulkheads which are closed by steel doors operated electrically by control from the bridge. (See article in *Scientific American* for April 19, 1913.)

It has been found by a Dutch investigator that at a temperature of three degrees above absolute zero the electrical resistance of mercury is only one ten millionth as great as at zero degrees Centigrade.

A cadmium vapor lamp has been devised by Dr. Wolfke. This vapor gives an excess of red light, but is corrected by adding a small amount of mercury. A lamp of 3800 candle-power uses 620 watts.

At the recent cement show in Chicago the National Bureau of Standards demonstrated the effect of electrolysis on the iron reenforcing rods of concrete. It was shown that local currents are set up in the iron, due to moisture and impurities, producing iron oxide. The oxide, occupying a larger volume than the iron, exerts a pressure which causes the concrete to crack.

The Department of Terrestial Megnetism of the Carnegie Institution will attempt this summer to locate as accurately as possible the focus of maximum total intensity of magnetism in the North, supposed to be in the vicinity of Cat Lake, near Hudson Bay.

A German war dirigible has been successfully equipped with a 40,000 c. p. search light.

The world's record for continuous and reliable wireless communications was made recently by the cruiser *Salem.* Complete day messages were sent up to 1300 miles, and received at distances above 2400 miles. Night transmissions were sent with clearness and without break for 3,000 miles.

The water of the Pacific has recently been let into the Western end of the Panama Canal.

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The report of the Committee on Magazine Literature, Fred H. Sawyer, Chairman, follows:—

Scientific American Supplement. March 22, 1913. "Wire Drawing. Methods and Machines Used in Manufacture," by Erik Oberg.

March 29, 1913. "Gyroscopic Stabilizer for Ships," by Elmer A. Sperry.

April 5, 1913. "Pioneers in Telephone Engineering. Experiences with the First Telephones," by Thomas A. Watson. "The Structure of the Atom. I. The Physical and Chemical Properties of the Atom Explained in the Light of Modern Theory and Experiment," by Sir. J. J. Thomson, F. R. S.

April 12, 1913, "The Structure of the Atom, II," by Sir J. J. Thomson, F. R. S.

April 19, 1913. "The Structure of the Atom, III," by Sir J. J. Thomson, F. R. S.

April 26, 1913, "The Structure of the Atom, IV," by Sir J. J. Thomson, F. R. S.

May 3, 1913. "The Structure of the Atom, V," by Sir J. J. Thomson, F. R. S.

May 10, 1913, "The Structure of the Atom, VI," by Sir J. J. Thomson, F. R. S.

Scientific American. March 22, 1913, "Measuring the Flow of a Stream. How Water Powers Are Accurately Calculated," by Richard Hamilton Byrd.

March 29, 1913. "Factory Methods of Testing Automobile Motors. How the Testing Block or Stand is Used," by Stanley Petman, M. E.

May 10, 1913. "Air Resistance to Falling Bodies," by A. A. Somerville.

Popular Electricity. May, 1913. Elementary Electricity for Practical Workers," by W. T. Ryan.

Electric Journal. January, 1913. "Shop Testing of Electrical Apparatus. I, General Instructions." (This is the first of a series of articles under this heading, describing in detail present day practice in the testing of various types of electrical apparatus.)

February, 1913. "Shop Testing of Electrical Apparatus. II, Resistance Measurements."

March, 1913. "Shop Testing of Electrical Apparatus. III, Insulation Testing."

April, 1913. "Shop Testing of Electrical Apparatus. IV, General Tests of Direct-Current Machines."

May, 1913. "Shop Testing of Electrical Apparatus. V, Direct Current Machines; Shunt and Compound Generators."

Harper's Magazine. May, 1913. "The Power That Serves," by Alan Sullivan.

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School Science and Mathematics. April, 1913. "The Teaching of High School Physics." "Physics From the Girl's Point of View." "Making High School Physics Real." "Boiling Point of Water—Experiment."

May, 1913. "The Projection of the Guinea and a Feather Experiment." "The Astronomical Telescope Drawing." "Experiment to Show the Physics of a Hammer Drawing a Nail."

Technical World. April, 1913, "To Electrify the Mountain Roads."

Popular Mechanics. April, 1913. "The Battle for Safe Water Supplies," by Dr. Allan McLaughlin.

Century Magazine. May, 1913, "A War Worth Waging," by Richard Barry.

World's Work. May, 1913. "Moving Picture Industry" (Editorial). "The Motion Picture Teacher," by Carl Holliday. "What We are Trying to Do," by 35 Teachers of the Washington Irving High School. "Making Foods of Chemicals," by L. K. Hirshberg, M. D.

Popular Science Monthly. May, 1913. "Great Erosional Work of Winds," by Dr. Charles R. Keyes.

The report of the Committee on New Books, Ralph C. Bean, Chairman, follows:—

A Review of the Revised "Millikan and Gale Physics."

The "First Course in Physics," by R. A. Millikan and H. G. Gale, both of the University of Chicago, appeared originally in 1906. It was a book which many of us have known by experience. The first edition contained 488 pages, and in some ways seemed to proclaim a new departure in the treatment of high school physics. The authors stated that they had not written it primarily from the college or mathematical standpoint, but had rather aimed at a text which should give a common sense as well as interesting explanation of the phenomena of the physical world. Another distinctive feature of the book was the use of the molecular theory as a basis in grouping subjects like Heat, Work and Motion. With many others, I introduced the book in my classes. In certain parts it was an inspiration, but in the subjects of Light and Electricity it was not satisfactory.

The Revised Edition, which has recently appeared, has evidently profited by the criticism which the former book received. It has been materially shortened, containing now only 442 pages. The paper is also thinner, making a book smaller than the former. In the former edition this statement is made, "The authors have endeavored to avoid sacrificing comprehensibility to condensation." In the present edition attention is called to the abridged form as one of the improvements.

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In following the books through in comparison it is noticeable that, while the headings are the same, the text has been made more concise, and in some parts whole sections have been omitted. It gives one the impression that it has all been gone over carefully.

In the first edition, after a chapter on measurement, which is in a way introductory, there follows the chapter on Force and Motion, taking up the Parallelogram of Forces, Newton's Laws, and Accelerated Motion. In the later book this is deferred to the fifth chapter. This is certainly a marked improvement.

The Molecular Theory still serves as a reason for separating various subjects which we are accustomed to see grouped together in Heat.

In the subject of Electricity the work is presented in the same order, but in the Dynamo and Motor it has been much simplified. Some of the more complicated paragraphs have still been retained, but in a finer print, which the authors use to indicate that it may be omitted.

In Light the text has also been made more simple and abbreviated. This time Refraction is taken up before Reflection, and Images Formed by Lenses before Images Formed by Mirrors.

The diagrams which characterized the former text, have been to a large extent retained and a number of new ones added. Among them are a thermostat, automatic float valve, Yale lock, and a Weston normal cell. The volt is defined in terms of the latter. A number of new illustrations which cover a full page have been added. The problems throughout the book are such as to inspire interest and call for thought. There are a number of pages of these grouped at the end of the book for review.

On the whole, the book seems worthy of our consideration as we look about for a text for our classes. There seems to be a strong appeal to interest and practicality which is in line with the present teaching of physics.

Mr. Boylston then asked for information as to how many of those present were using the Millikan and Gale. The outcome of the question was a general question about what books were being used. The following list shows how many schools are using each of the books mentioned: Millikan and Gale, 9; Mumper, 13; Hall and Bergen, 6; Wentworth and Hill, 4; Linebarger, 3; Carhart and Chute, 2; Gorton, 2; Mann and Twiss, 2; Cheston and others, 1.

On recommendation of the Executive Committee, Professor George F. Bacon, Simmons College, was elected to associate membership.

Mr. Packard arose to speak informally on the matter of the attempt to reorganize the secondary school curriculum throughout the country, stating that this matter of reorganization had been divided into

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groups and sub-groups, naming the members of the group and sub-groups of science.

He then told of the work of a joint committee of which he had been one, the efforts of which have been to introduce commercial forms of apparatus into the physics laboratory. The outcome of these efforts so far has been the monographs that are being sent out by the Weston Electric Company.

On motion it was voted that Mr. Packard represent this Association formally in any matter of this sort.

Here followed a discussion of the question, "Should the Course in Secondary School Physics be the Same for Girls as for Boys?"

Mr. John C. Packard of Brookline High opened the discussion with an outline of a course in sound and music that he has just been giving to a class of girls in his school.

"SOUND AND MUSIC."

OUTLINE OF COURSE AS GIVEN TO JUNIOR CLASS OF FIFTEEN GIRLS.

A. *Study of Tuning Fork. Pitch.*

1. Savart's Wheel, with four discs, giving the tones c, e, g, c^1 40, 50, 60, 80 teeth, various speeds.
2. Number of vibrations per second determined by use of a siren.
3. Galton's Whistle. Limits of audibility, 16 to 38,000 vibrations per second; limits of musical sounds, 16 to 4,300. Piano range.
   1. *Laboratory Exercise.*—Tuning Fork. Pitch determined by the Siren.

B. *Study of a Vibrating String.*

(*a*) *Swinging Cord.* Showing vibration as a whole, as in parts or segments.

Definitions. "Ventral segment," "node," "amplitude," "pitch," "period."

(*b*) *Guitar String.* Law of lengths, law of diameters, law of tensions, combined law. $N = \frac{C}{L} x$ square root of $\frac{T}{M}$.

To find C.

"Partial vibrations," "octaves," "harmonics," or "overtones"—located on the piano and plotted on music-plotting paper. First ten harmonics of C^1.

2. *Laboratory Exercise.*—Sonometer. Finding value of constant C in Formula. Locating overtones.

C. *Study of Wave-Motions.*

(a) *Water Waves.—Definitions.* "Crest," "trough," "wave-length," "re-enforcement," "interference," "amplitude," "velocity of transmission."

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(b) *Sound-waves.* Slides to illustrate longitudinal waves in air. (1) moving slide, Crova's disk; (2) waves made by a vibrating bell; (3) waves caused by an explosion.

Definitions. "Condensation," "rarefaction."

D *Study of an Air Column—Resonance.*

In a glass graduate locate level of water below mouth for maximum loudness of F—fork of known pitch, vibrating over mouth; measure diameter of jar, determine wave-length and velocity of sound in air.

3. *Laboratory Exercise.—Resonant Column.* Cylindrical tube and sliding piston.

E. *Study of a Pair of Tuning Forks.*

Sympathetic vibrations.

F. *Study of Stringed Instruments.*

Slides. Mandolin, banjo, guitar.

Harp.

Pianoforte.

Violin, viola, violoncello, contra bass.

Tuning. Range, as used in orchestra. Plotted on music plotting paper.

4. *Laboratory Exercise.*—Plotting musical range of stringed instruments.

G. *Study of the Human Ear—Hearing.*

Slides. The external and internal ear.

5. *Laboratory Exercise.*—Ear Test. New Apparatus, Solenoid Hammer.

H. *Study of Bach's Evenly Tempered Scale.*

Melody, harmony, illustrations, dinner chimes.

Mathematical discussion.

Chromatic pitch pipe. Standard pitch. A = 435, 440, 442.

Illustration. Oliver Ditson's Standard Forks.

I *Excursion.*

Visit to a Piano Factory. Chickering's, Boston.

J. *Study of an Organ Pipe.*

Open and Closed Pipes; Nodes and Antinodes, Overtones.

Voicing. Gas Jet and Resonant Column for Heavy Bass Note.

6. *Laboratory Exercise.—Voicing an Organ Pipe.*

K. *Study of a Reed.*

Various Kinds. Illustrations,—early instruments, harmonicas, cabinet organs.

L. *Excursion.*

Visit to an Organ Factory. Hutchings', Waltham.

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M. *Study of Orchestral Instruments.—The Wood Wind Type.*
Characteristics of Individual Instruments.
Slides. Piccolo, flute, oboe, clarinet, bassoon, saxophone. Range, plotting.
Victor Records.

N. *Study of Orchestral Instruments.—The Brass Wind Type.*
Characteristics of Individual Instruments.
Slides. Trumpet, horn, trombone, baritone, bass tuba. Range, plotting.
Victor Records.

O. *Study of Orchestral Instruments.—The Percussion Instruments.*
Slides. Drums, cymbals, triangles.
Victor Records..

P. *Study of the Orchestra.*
Principal Instruments. Emotions expressed by each.
Slides. Grouping of orchestra.
Victor Records.

Q. *Study of the Human Voice.*
Men's voices, women's voices. Range, plotting.
Quality. Victor Records.
Slides. Vocal cords.

R. *Excursion.*
Visit to a church organ.

S. *Concert.*
Piano, violin, voice.

REFERENCES:

Sound and Its Relation to Music. Clarence G. Hamilton.
What We Hear in Music. Anne Shaw Faulkner.
Music and Musicians. Lavignac.

Dr. Leslie L. Campbell of Simmons College spoke on the subject as follows:—

In reply to the question of the topic before us, I would suggest the following propositions:—

1. The *fundamentals* of physics are always and everywhere the same, irrespective of sex.

2. To acquire a *working knowledge* of these fundamentals of physics, the work must be done largely in *quantitative* form in the laboratory and by the solution of many *numerical* problems.

3. The *applications* made of the principles of physics, the *appliances* studied, and the *laboratory exercises* should not necessarily be the same for boys and girls.

Mr. Irving H. Upton of Roxbury High School continued with the following:—

A few years ago I presented a paper before this Association stating why I thought physics a suitable and profitable study for

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girls, how it could be made more attractive to them, and what should be the aim of the teacher in arranging and planning his course. After the lapse of time it is interesting to compare one's views as stated then with those of the present, made clearer by experience since gained.

Perhaps no feature of educational policy has come in for more emphasis of late than vocational training. Training for formal discipline may not be any the less appreciated, but certainly the practical element is uppermost in all our professional thought today. Any subject to get a foothold, or retain it when once gotten in the educational field, now must do so by demonstrating its value for the people in no uncertain and practical manner. Let me repeat then that what I said about physics for girls some years since could be said with even greater firmness today because of the trend of subsequent events of the educational world, and because the subject matter of the science lends itself so naturally and easily to the demands of the modern life of today.

The old idea that girls could not *enjoy* and certainly could not *master* physics is fast disappearing. This is due to a slightly changed point of view on the part of instructor and text-book writer, partly to better laboratory facilities, and partly to more reasonable demands by higher institutions of learning. The pendulum then is shifting from the formal, rather mathematical, unrelated presentation of the subject, to the practical and useful presentation, more directly connected with the life interests of the child.

I am strongly convinced that the course in secondary school physics should be definitely and clearly adapted to the needs and requirements of the pupils taught, and hence believe that a different content as well as different treatment is demanded for girls than for boys. If we grant at the outset that buildings, equipment, texts and teachers exist for the pupil, it is foolish not to attempt to adapt our material and methods to the needs of the pupil. What, then, shall be the content and treatment in physics for girls?

First, who constitute the girls we teach, whence come they, and whither do they go? They come from all kinds of homes of varying conditions, from an ancestry of equal variety, and bound for various destinations and stations in life. In the vocational schools they are bound for the office, the store, and the shop, as well as the home; in the Latin School for the college, in the general school they are fitting for "life," as it is called, but in all cases it is in reality for life, and a great majority of these girls are to be home-makers, fortunately. It is incumbent on us then as guardians of this science for these people to so arrange the content and plan the presentation of it as best to meet these varying needs. As a Normal School teacher puts it: "The ability to appreciate the value of a fireless cooker, or a thermos bottle, or the ability to buy an electric iron to fit conditions, or to reject a filter because the underlying scientific

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principle is understood, is certainly of value. If a girl understands the kitchen boiler, the gas range, electric devices, ventilation and heating of her home, and the plumbing system sufficiently to know when she needs to employ a plumber and when the problem is simple enough for her own solution, she will have plenty of real solid work to do in school."

It is needless to say that much of what we have taught should be omitted, and many new features should be included for girls. If we can so co-relate the subject to every-day life that it shall challenge the interest of the pupil (as it will) we have gained a quickened interest and enthusiasm, which is one of the largest assets toward success in the enterprise. What, then, shall we teach? I am not ready to make a hard and fast curriculum, because it should be varied from time to time, and adapted to different sets and kinds of pupils. The outline of topics made today will require modification tomorrow, for educational ideas are more or less in a state of flux at present, and the needs of today will not be felt so acutely next year, when new adjustments will be necessary to meet new conditions.

We need to vary and modify our outlines of instruction and lists of experiments, and these will always be improved if each time we readjust them we get into more thorough sympathy with the varying needs of our pupils; this readjustment is as valuable for the teacher as for the pupil, for it prevents stagnation.

But what I have been trying to do primarily in my work this year is to open the eyes of pupils to some of the beauties and wonders in the natural world, and thereby inculcate a love for Nature; secondly, to teach the pupil to think carefully, accurately and logically, and I have found an abundant field for effort, especially in this latter direction. I have found that girls respond readily to an effort to interest them in the remarkable things of nature quite as promptly as boys, if not quite so deeply; that they keenly appreciate the practical side of it, particularly if connected with the home, and that they will go to considerable pains to attain some point when thoroughly interested in it.

To be more specific then as to the content of the course: for girls I would put great emphasis on the subject of heat, to be followed by electricity, sound, and light, in order of importance. Mechanics? Yes; but I feel that most of us devote an unwise allotment of time and energy to mechanics; for much here has no bearing upon the life of the average girl; much she can learn by observation and reading, and the rest can be done in much less time than we usually give to it. The topics of movements, couples, accelerated motion, errors in spring balance, breaking strength of wire, torsion, etc., could be better omitted, and the time given to such themes as home ventilation, home plumbing and heating, gas-meter, efficiency of gas stove, the cook stove and hot-water tank, etc. The subject of sound

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is favorable for the consideration of girls because many are musical by nature, some are studying vocal or instrumental music, and many will teach where a knowledge of the theory of music is required. So I include this in my list of topics today. But I am inclined to think the subject of heat offers as wide a field for coming in contact with the daily life of the girl and future woman as anything in physics.

Third, I would make a large point of electricity and its numerous applications in the complex life of today, even with girls; and I would do this first for its own sake, and second, because of the many ways it touches every one's life. The electric flatiron, washing machine, coffee grinder, sweeper, toaster, sewing machine, yea, even "my lady's toilette," all bear evidence of the great service electricity is rendering to the woman of today.

Fourth, I would include a fairly thorough treatment of the subject of light in a girls' physics course of today, for much the same reason as the other departments of physics. The facts of intensity, reflection, refraction, mirrors, color, photography have many contacts with every day life and can be made interesting and practical to girls.

Perhaps if we sifted into the course some of the most inspiring things from the history of science, which has been a long and glorious one, we should arouse more interest in the subject. The biographies of great discoverers will quicken an enthusiasm which we might otherwise lose. A girl will hunt up facts about Sir Isaac Newton, or Gallileo, or Marconi, and get thereby a momentum for the next day's hard lesson which would otherwise be missing.

Let us then make the course modern and up to date, and have it touch life at every possible point. Let us correlate physics to other subjects, earth science, geography, elementary astronomy, the plant world; even a little chemistry mixed in will do no harm, and thus introduce these girls to more than one avenue to the great workshop of Nature.

I close these brief observations with a thought similar to the one expressed at the close of my remarks four years ago:—

Our primary aim should be to cultivate the power to think, the ability to master difficulties and situations; in a word, self-control. In our desire to interest let us not lose sight of the disciplinary value our subject should have and will have for the pupil if he be guided and directed aright. When he has gained this, the physical world will have a different meaning for him, and his life will be fuller, richer and better.

Mr. Walter G. Whitman, of the Salem Normal School, then ended the discussion with the following:—

But a few wears ago practically all our high school physics teachers were teaching to all pupils one and the same course in physics. It

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was a course designed to prepare boys to continue advantageously in college. It was asserted that the same course was also best for students who never would enter college, and as good for the girls as for the boys.

From my own experience I believe many of the physics teachers took the doctrine on faith and taught physics as outlined in college entrance requirement syllabi, without giving the matter of suitability of such a course to the majority of their students, serious thought. There have been all the time a few physics men who never were convinced that a course devised primarily for ten per cent. of the high school graduates could at the same time be the one best suited to the needs of the other ninety per cent.

Experience in teaching class after class has convinced many more teachers that while there has been a large amount of good done by this very formal scientific course, yet it does not entirely meet the requirements of our present students.

The high school teachers are the experts in teaching high school physics. They are men with special training for their work. Nobody is better qualified than the high school teachers, to decide what should be the content of a course in physics for pupils in the high school. College professors are recognizing this and many of them are ready to "OK" a course of study in physics which the high school physics teachers agree upon. The colleges have made substantial concessions in entrance requirements, giving the teacher more latitude in treatment of the subject. The tide has already turned away from college entrance as the ruling idea in planning work for the high school. There is in existence throughout this country today a powerful movement for a "practical science." A science that can be used in every day life,—not to be stored up entirely for some future day, but for use *now* and in the *future* too.

The trend of present day education seems to be increasingly more toward a segregation of the sexes. More than ever before educators are advocating separate classes and separate schools for girls. One important reason given for the separation in class work is that the girl needs in a measure different information from that given to boys.

There are hundreds of science teachers all over the country today, believers in a special girls' course, working on this problem of selecting the best material in physics for girls. These teachers either have separate classes for girls or are waiting for the opportunity when they can secure them.

Is this idea of separation only a new fad or is it fundamentally correct and likely to become a fixture? Let us consider for a moment the girl who graduates from the high school. She may go to college, to normal school or to some other school for special training. But it is only a few years before the majority of them marry and take up the duties of the home. She may find employment as a

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clerk, a stenographer, in a factory, or may help at home. Soon, however, the majority of these will, too, have their own household to care for.

One can scarcely comprehend in a brief time the enormous change that has resulted from the introduction of devices involving physics into the household in the last few years. Electricity and gas in a quarter of a century have revolutionized the household. Science has solved many of our home problems, but has given the teachers additional ones.

With lighting, heating, and cooking devices, bells, thermostats and telephones, washing machines, sewing machines and ice cream freezers, motor driven; phonographs and mechanical piano players, vacuum cleaners and artificial refrigeration; with all these and more in successful operation at the present time we can but wonder—we cannot foresee—we can but wonder what will be the equipment of a modern home in another quarter of a century, should the development of applied science continue at its present rate of uniformly accelerated speed.

Not only in the home, but even more in the industries is science manifest today. As our industries become conducted more and more upon a scientific basis, it is not merely the engineer, the man with a technical education, who must understand practical science, but more of the rank and file of the industrial workers must have some knowledge of physical principles and ability to apply them.

A boy in high school may secure much of this kind of training by pursuing a course in physics which is adapted to industrial processes.

One-third of our laborers are engaged in agricultural pursuits. By a special treatment of topics of agricultural physics, the course may be made of much practical value to a large number of high school boys.

These useful devices of the home and the better equipment and processes in the industries are possible because science has been made practical. But in this very practical way, science has imposed a burden upon the schools. There is no longer any question about the necessity of a wider knowledge of practical science. The responsibility of teaching it rests upon the public schools.

An important end in physics should be to produce observing and thoughtful boys and girls. We wish to develop initiative and an ability to test things and to find things out. While our method of treatment is of great importance here, the subject matter too, will largely determine the degree of success attained. If our subject matter is foreign to the life of the pupil, he is likely to think that physics is to be used only occasionally, but if the subject matter is full of the things and problems with which he is in daily touch, then whenever these daily problems present themselves, physics is suggested as a real and useful friend.

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We should strive to make the students realize that physics will always be of use to them if they will keep an open, scientific mind and apply scientific methods to their problems. For example, a gas-stove bread-toaster on first trial burns the bread on the bottom edge without toasting it at all on the upper edge. There are hundreds of people who would condemn the toaster and discard it at once. One important object of a physics course should be to change the attitude of the students so that they, under like circumstances, would inquire, "why is it that the bread burns on the bottom edge only?" By a little serious thinking and some experimenting, it might be discovered that the gas plate should be of a smaller diameter, and when used over a proper flame excellent toast may be made.

There are so many physical devices in every day use that no one can be ignorant of the principles involved in them without feeling the lack of such knowledge.

The boy and girl both need much science in common, that they may understand the many natural and man-produced phenomena. Let us call this knowledge, cultural. Beyond this, the courses should differ.

The principal difference in the courses will result from a fuller treatment of the physics related to industries in the boys' course and of the applications to the household in the girls' course.

A boy should get from physics much of cultural value, as the explanation of common natural and artificial science problems which he meets daily, explanations of the things which intensely interest him, and especially a fundamental knowledge of mechanical and electrical machines, instruments and operations.

A girl should get from physics much of cultural value and an abundance of interesting and useful material related to household processes and devices.

Household science is largely physics. It is comprehensive, including, as it does, such a variety of subjects: the action of the trap in the sink drain, why pop corn pops, pasteurizing milk, electric fuse wires, ventilation, indirect lighting, the chafing dish, the coffee percolator, the refrigerator, preserving foods with heat, preserving foods with cold, city water distribution, dangers from electric wires, advantages of underground conduits, etc., etc.

Household science might well make up a large part of a girls' course in physics, but such extensive treatment of these subjects in a boys' course would crowd out much material of special value to boys. The course in domestic science, when given, may cover some of these household subjects, but it is impracticable to cover the field in such a course. The two departments might correlate the work to good advantage.

If a course of study should be planned in part with a view to the future, then pre-eminently should the girls' training tend toward the home, not the isolated home, but the home as an integral part of

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the community, a home with its interests and activity projected into the community interests. The woman of today and the future is not confined to the walls of her house, but is a helpful friend and often an active participant in public affairs and civic improvement.

The home is the place with which girls are most closely associated and the making of a home is the end toward which most girls are working. With modern mechanical and electrical devices, it is comparatively easy for a woman to manage the home without a maid and still not be a slave to drudgery.

Physics more than any other subject in the high school may be so planned that it will teach the girl the principles which are fundamental and which make intelligent use of the many labor saving devices possible.

In the normal school our point of view is different than that of the high school. Our courses are professional, that is, we must prepare the girl to teach, and while we do not intend to overlook the cultural value of a subject, we have no right to take time to teach girls household science except as it may be reflected in their own teaching.

Household physics is needed by every woman. The colleges which offer such courses can reach but few. The normal schools cannot give it. The obligation of providing better education in this direction rests upon the high schools. The high schools can give a broad and full treatment of these subjects. The high schools are able to reach large numbers of girls and they may thus contribute both to domestic improvement and to civic betterment.

Here followed an inspection of the physics laboratory of Simmons College, in which were seen several pieces of apparatus of a practical nature. Among these were included a metal model of a hot air furnace, recording gas meters, both dry and wet, a telephone system of two individual and a central station.

Lunch at the Art Museum was taken by most of those present.

AFTERNOON SESSION.

Mr. Le Sourd, who could not be present at the morning session, opened with a talk on some uses of compressed air. He first enumerated some of the commercial uses, including air brake, sirens, cash and mail carriers, caissons and diving bells, torpedo tubes, pneumatic hammers, drills and riveters, in refrigeration and in the manufacture of liquid air.

For a laboratory equipment for supplying the compressed air he suggested a pump with cylinder four inches in diameter and six-inch strope of one and one-half horse power, capable of taking in seven cubic feet of air per minute and compressing it to 150 pounds

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per square inch. By means of a reducing valve this could be reduced to ten pounds, a force sufficient for most experiments.

With various pieces of apparatus, easily secured or made, he showed many interesting experiments, some of which to the uninitiated would be quite startling. Among the latter was the case of a ping pong ball suspended in air by a stream of air from a glass tube at a 45° angle; the same ball rotating inside a glass funnel held horizontally, where a stream passed out from the large end; a piece of cardboard held against a flat disc, from the center of which the air was being forced.

The frictional effect of pipes was shown by two tubes of different lengths pointed so that the air from each would fall on opposite sides of a fan wheel. The shorter tube opening could be held some distance farther away and still counteract the effect of the air from the longer one.

Among the other possible uses are in showing the cooling effect produced by evaporation of water and ether, the action of the atomizer, and the glass cylinder steam engine. In the chemistry laboratory, compressed air may be used for drying tubes, stirring liquids and the blast lamp.

Mr. John Hamilton then spoke on the life of Lord Kelvin and of his association with him.

"LORD KELVIN."

It was with considerable diffidence that I consented to appear before your Association today and address you upon the subject of Lord Kelvin for the reason that my contact with his Lordship was of a very remote and limited nature, and even this contact, such as it was, did not come into existence until the latter portion of his Lordship's life, when he was already a comparatively old man.

I observe from your printed programme that I am referred to as one who was with his Lordship in his laboratory; I want to clear that matter up by stating that this should be distinguished from the Glasgow University laboratory, where of course his Lordship supervised the work of his students.

I came in contact with Lord Kelvin (then Sir William Thomson) through the laboratory and workshop of James White, Scientific Instrument Maker, 18 Cambridge Street, Glasgow, and as I first saw him (Sir William) he was an enthusiastic inventor, coming into the laboratory and workshop daily to work upon the development and perfecting of what seemed to be an unlimited and exceedingly varied line of patented scientific instruments.

At this time Sir William was a grey bearded, venerable looking gentleman, and I was a high school boy, considerably overawed by the immensity of the world of physical science which lay before me for my investigation, and at the same time painfully conscious of my

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own limitations. Naturally as I learned more and more of Sir William's life and past achievements he began to stand forth in my mind as a veritable hero, a towering giant who seemed in the contrast to ruthlessly cast in the dust all my hopes and ambitions to ever know anything of physical science.

Consequently it was with considerable avidity that I read every record I could find of the origin and early life of this wonder, with the particular objective of finding out if he had really ever been a boy like me and had ever known so little.

He came of what is called here Scotch-Irish stock, having been born in 1824 on the outskirts of Belfast, County Down, Ireland. His father before him was the son of a comparatively poor farmer and was evidently unable to begin his university studies until he had earned at least *some* of the wherewithal.

Strangely enough, Lord Kelvin's father came to Glasgow for an education, entering Glasgow University in 1810, and Lord Kelvin, like most men, seemed ever ready to relate incidents and experiences in his father's college life, one of which was that it very frequently took a week to go from his home in Belfast to his University in Glasgow, a journey which modern steamships accomplish in about eight hours.

Mr. James Thomson, the father of Lord Kelvin, after leaving a very creditable record as an undergraduate at Glasgow University, was elected in 1818 to the professorship of mathematics in the Royal Academical Institution of Belfast. During his tenure of this office he published many mathematical works and compelled his recognition by the scientific world of his day as an indomitable worker and a clear thinker. Consequently when in 1832 the chair of mathematics at Glasgow became vacant, the faculty, which in these days seemed to be the governing board, very naturally turned to its own honored offspring, with the result that Prof. James Thomson, with a family of young Thomsons, became Glasgowegians in that year.

The family consisted of the father, four sons and two daughters. The mother, who, by the way, was a native of Glasgow, and would have taken a peculiar delight in this triumphal return to her native city, was not allowed this privilege, having died a short time previously.

In these days it was customary for college professors to accept as part of their remuneration or stipend a residence in the college yard, so we find in due season the young Thomsons were admitted to the companionship and chumship of the children who already were favored to play within the college gates, all of whom had homes in Professors' Row.

But what a place to bring children when judged by our standards and points of view of today. I shudder to think of it as I have known it, and as far as I can learn it was even worse in the days when the Thomson children were brought within its sphere.

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The old Glasgow College, like most colleges of these days, was located right in the heart of the city, on a site towards the top of High Street, and in a particularly slummy and degraded section. It almost baffles the imagination of the present day to picture such a world as that which was enclosed within the college walls, a world completely wrapped up in its intellectual life and sufficient unto itself, its tranquillity not at all apparently disturbed by the ever present signs of human misery, ignorance, crime and degradation, which arose all around it and assailed the common senses of sight, hearing and smell, even within the innermost recessess of class rooms, dining rooms and dormitories.

Perhaps I cannot do better than quote a little of Prof. Ramsay's description of the place as it impressed him while a student in the place, and I think you will find, even in his description, that a consuming altruism or a devouring passion for the salvation of human souls was not a dominating characteristic of intellectual men in those days. Prof. Ramsay says:—

"There was something in the very disamenities of the old place that created a bond of fellowship among those who lived and worked there, and that makes all old students to this day look back to it with a sort of family pride and reverence. The grimy dingy low-roofed rooms; the narrow, picturesque courts, buzzing with student life; the dismal foggy mornings and the perpetual gas; the sudden passage from the brawling, huckstering High Street into the academic quietude, or the still more academic hubbub of those quaint cloisters, into which the policeman, so busy outside, was never permitted to penetrate; the tinkling of the "angry bell" that made the students hurry along to the door, which was closed the moment that it stopped; the roar and the flare of the Saturday nights, with the cries of carouse or incipient murder which would rise into our quiet rooms from the Vennel or the Havannah; the exhausted lassitude of Sunday mornings, when poor slipshod creatures might be seen as soon as the street was clear of church-goers sneaking over to the chemist's for a dose of laudanum to ease off the debauch of yesterday; the conversations one would have after breakfast with the old ladies on the other side of the Vennel not twenty feet from one's breakfast table, who divided the day between smoking short cutty pipes and drinking poisonous black tea,—these sharp contrasts bound together the college folk and the college students, making them feel at once part of the veritable populace of the city and also hedged off from it by separate pursuits and interests."

This may serve to give you some idea of the environment into which in 1832 Professor Thomson brought his family, consisting of the two eldest girls, Elizabeth and Anna; the oldest son, James, aged ten, future professor of engineering; William, aged eight, the future Lord Kelvin; John, aged six, a future distinguished M. D.; and Robert, aged three.

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Considering their environment the Thomson children were fortunate in having a father who realized the corresponding increase in his responsibilities toward them, for he had their education attended to in the home, and applied the strict discipline which characterized him in the class rooms to the training of his children at home.

In 1834, that is, at the age of ten, William Thomson entered the University classes, and with his brother James as a close second, he invariably carried away the honors in his classes. In 1838-9 William gained the class prize in astronomy and secured a University medal for an essay on "The Figure of the Earth."

In 1840, when his sons James and William, aged eighteen and sixteen, respectively, had completed their college courses at Glasgow, Professor Thomson took them off to tour through Germany, with the understanding that the German language should be the only subject of study during the summer vacation. William, however, had just begun to study Fourier, the French physicist's famous book, "La theorie analytique de la chaleur," and took it with him. He read that great work, full as it was of new theorems and processes of mathematics, with the greatest delight and finished it in a fortnight, and as a result produced his first original paper on "Fourier's Expansions of Functions in Trigonometrical Series," which is dated Frankfort-on-the-Rhine, July, 1840, and Glasgow, May, 1841, and was published in the *Cambridge Mathematical Journal*, Vol. 2, May, 1841.

From this time on William Thomson made many contributions to educational literature, principally, however, on the subject of higher mathematics, and it was even predicted that he, like his father, would shine as a mathematician.

He left Glasgow and went to England in 1841, now seventeen years of age, and in that year took up in Cambridge University the course of study then in vogue for mathematical honors. Here he surprised every one by his indomitable energy in the amount of work he accomplished entirely outside of that required by the curriculum; he read mathematical books altogether outside the scope of the tripos, and contributed original articles to the *Cambridge Mathematical Journal*. In the line of athletics he won the Colquhoun sculls as an oarsman and was an active member and later president of the Cambridge University Musical Association.

During his term at Cambridge Thomson formed friendships with students who afterwards became shining lights along their special lines, notably that with George Gabriel Stokes, who became an eminent mathematician and physicist.

Thomson himself however, began at this early age to receive considerable attention, due to the brilliancy and originality of his contributions to mathematical and philosophical discussions and journals.

His contemporaries began to realize that mathematics was not his goal, but by his remarkable facility as a mathematician and his

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wonderful powers of enthusiastic application, he was commanding attention in his enunciation of new and original theorems and laws in the realm of physical science. During this period considerable excitement had been produced by the announced discoveries of Oersted, Ampere, Henry, Farady, Regnault, Gauss and Weber.

These men had discovered that by producing certain physical conditions other physical conditions were produced as a result or incidentally, and to the philosophers, or what we might call the lawyers of physics, the whole world looked for a definition or an explanation of these results.

In May, 1846, Professor Meikleham, who was the then incumbent of the chair of natural philosophy in Glasgow University, died, and a minute entered on the records of the faculty under date of September 11 reads thus: "The faculty having deliberated on the respective qualifications of the gentlemen who have announced themselves candidates for the chair, and the vote having been taken, it carried unanimously in favor of Mr. William Thomson, B. A., Fellow of Saint Peter's College, Cambridge, and formerly a student at this University, who is accordingly declared to be duly elected; and Mr. Thomson being within call appeared in faculty and the whole of this minute having been read to him, he agreed to the resolution of the faculty above recorded and accepted the office." It was also resolved as follows: "The faculty hereby prescribes Mr. Thomson an essay on the subject, 'De caloris distributione per terra corpus,' and resolve that his admission be on Tuesday, 13th October, provided that he shall be found qualified by the meeting and shall have taken the oath and made the subscriptions which are required by law."

At that time and until some years later every college professor before his induction was required to submit an essay written in Latin on some prescribed subject. This was probably the last remaining relic of the days when college lectures were delivered in Latin, and even this relic was cast aside by Adam Smith upon his assuming the chair of moral philosophy also at Glasgow University.

On the appointed day (13th October, 1846) Professor Thomson presented the thesis as required, and having satisfied all other conditions, he was duly inducted into office as professor of natural philosophy, at the remarkable age of twenty-two years. Thus was created a professional relationship which proved to be so mutually congenial and beneficial that it was only severed after fifty-three years of the most ardent and devoted labor, when in 1899 Thomson (then Lord Kelvin) was compelled on account of his age to resign his professorship.

We find that Thomson's enthusiasm immediately began to make trouble for the faculty; he was first, last and all the time, an investigating philosopher, and one almost gets the impression that he believed that anything and everything was justified if it aided him in the pursuit of his all-absorbing profession. To his mind, what

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was the importance of etiquette, faculty's rules of procedure, or even admonition, in the face of the all-absorbing pursuit of the laws which govern the distribution of energy in a body, the cooling of a sphere, or the heat equivalent of energy dissipated.

It seemed as if this new young professor was all the time requiring new apparatus and, when his rather scant supply of patience was exhausted, ordering the same without the faculty's consent or approval; he was overworking his students, keeping them late, and bringing them in early, and then monopolizing and preempting as laboratory rooms, other parts of the college not officially assigned to him.

One can readily appreciate that some of Thomson's characteristics would have prevented the average man from holding his professorship for 53 years, but his unstinted self-sacrifice, his absolute self-consecration to science, while it very frequently involved others, who, not sharing his enthusiasm, were less cheerful, always won for him, at least toleration, and most always admiration. He seemed to consider everybody and everything, not exempting himself as fit and appropriate sacrifice for the Gods of Sound, Light, Heat, Magnetism, Electricity and Dynamics. We find him in the first few years of his professorship, in papers and lectures, bemoaning the lack of proper standards for scientific measurements and urging all to give themselves over to this determination.

We talk today of our volts, amperes, ohms and farads with as much facility as the marketmen talk of their pounds, quarts, pecks, etc., and do we any more than they stop once in a while to pay our respects to the men who in darker days applied themselves to the rather inconspicuous and thankless task of developing our standards

For instance, in one of the papers of that day we find reference made to a piece of wire which had been used in a certain experiment as having a resistance equal to one and three-quarter times the resistance of another piece of wire in the possession of Professor So and So at Cambridge University, and in days of undeveloped transportation facilities, a very tedious journey was necessary to learn even that much.

No connected or continued line of thought or investigation was possible under such circumstances; the results of the research of one man could not be taken up by another. The burden of this handicap led to the appointment by the British Association of a committee on standards, and when this committee made its first report in 1862, it consisted of Professors A. Williamson, C. Wheatstone, W. Thomson, W. H. Miller, Dr. A. Mathiessen and Mr. F. Jenkin.

From this committee, of which Thomson was a pillar, we received what is now the practically universal system of C. G. S. and B. A. units. Thomson put a vast amount of work into the results obtained by this committee, and one wonders how he found the time and the

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energy to accomplish so much outside of the performance of the duties that were attached to his professorship in the University.

Into these busy years also was crowded another important task for Thomson. In 1857 he was commissioned as an expert representing the British Government in the laying of the cable which was to connect Great Britain and America in telegraphy. We are all familiar with the enterprise to which the two governments made equally substantial subsidies in the form of money, men and ships, and the first successful tying together of the two countries (after three failures), with Cyrus Field as general manager of the Atlantic Telegraph Company, aboard the U. S. S. *Niagara*, and Professor Thomson aboard H. M. S. *Agamemnon*.

We can readily imagine the rejoicing on receipt in this country of the first flashed message in the form of congratulations from Queen Victoria to President Buchanan on August 6, 1858. We can also picture the feelings akin to despair when it was reported that signals had ceased and the cable was broken exactly one month later. Thomson had supervised the manufacture of this cable in England, as well as its laying from the *Agamemnon*, so he was called upon to investigate the cause of the break.

He reported a flaw in the manufacture of the cable and the fact that too heavy potential had been applied to the cable in the effort to drive the signals through it; also that the signalling apparatus was too heavy and clumsy, requiring too much power to operate. Then there was an interval without telegraphic communication between the two countries, and in this interval the Atlantic Telegraph Company was reorganized as the Anglo American Telegraph Company; the *Great Eastern* was built and Thomson invented his mirror galvanometer.

I must stop at this point to remark that every practical electrician knows what a boon this mirror galvanometer has been; as well as solving the problem of long distance cable signalling, it has made accurate and delicate electrical measurements possible. We find this principle invented by Thomson in use today in quite a variety of forms, perhaps the most common being that in the D'Arsonval galvanometer.

With many improvements incorporated in both cable and apparatus which had been developed from the preceding disastrous experience, we find Thomson setting out again on board the *Great Eastern* in 1865. In 1866 communication between the two countries was again established, and we all rejoice in the fact that it has never been interrupted since.

Thomson returned to Glasgow after this exploit a veritable hero; he was lionized in all sorts of forms, receiving the freedom of the city and a knighthood from Queen Victoria. All sorts of submarine cable companies were then organized and enterprises launched and

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both foreign and domestic companies vied with each other in their efforts to secure Thomson's services as consulting engineer.

Up to this time I should say Thomson's busy life had brought all of its fruits almost entirely to the upbuilding of the scientific world in general, with little or no pecuniary advantage to himself, but it does seem as if his experiences aboard the *Agamemnon* and *Great Eastern* impressed on him the need of a great deal of practical apparatus, especially in the line of navigation; it seemed as if the patents literally flowed from his fertile brain, and almost any one of these patents would be sufficient substance for a whole treatise.

One of the most important perhaps is the siphon recorder, which took the place of the mirror galvanometer in cable telegraphy; this is used in submarine telegraphy today all over the world, giving a permanent record of every message, and consists of a thread-like glass tube (vaccination tubing in reality) bent so that one end hangs in an electrified ink well, while the other hangs in close proximity to, but does not touch a paper ribbon; the siphon forms part of a movable structure controlled by a suspended coil which receives its impulses from the signal current; the electrified ink is drawn from the siphon in a beautiful continuous line, while there is no contact and consequently no friction between the siphon and the paper.

Next comes the mariner's compass, which created an epoch in navigation, producing a compass based on the finest developments of science up to date; while the compass hitherto used had been crude and clumsy, the Thomson compass was delicate and sensitive; while its predecessor had been easily influenced and deflected by magnetic disturbances in the hull or machinery of iron ships, the Thomson compass was surrounded by correctives and neutralizers for such disturbances. Auxiliary apparatus that goes with Thomson's compass are the azimuth mirror for taking observations of the sun's bearings in adjusting the compass, and Thomson's magnetic deflector, which enables deviations to be read and corrections to be made for any compass without regard to the sun's bearings. The next time any of you are on deep sea-going ships just take enough interest to look up Thomson's compass and also his sounding machine. This latter machine relegated the heaving of the log to a somewhat sudden antiquity; by its use our fast modern ocean greyhounds are enabled to take soundings in rapid succession which tell the depth of water and the nature of the ocean bottom without any reduction in speed.

The navies of every nation in the world and all high class merchant ships are equipped with these instruments.

My recollections of an apprenticeship in White's laboratory and workshop, where all of Lord Kelvin's apparatus was made, would tempt me to become reminiscent and go into the details of some of these instruments, but time forbids it. Just let me state that at the time, I considered myself privileged in being allowed to work on,

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and with, apparatus that represented so much of the highest attainments of science. I appreciated also the inspiration that came from the personal supervision and co-operation of the honored and aged inventor himself; his zeal and enthusiasm, exemplified in his regular daily visits to the shop and laboratory, although handicapped by age and an accidental lameness.

I well remember being impressed with Lord Kelvin's concentration on the task in hand; concentration to a fault, which resulted often in annoyances and inconveniences to other people, as well as to himself. Here is one of the many stories which well illustrate it: Lord Kelvin was preparing an article on heat for the Encyclopedia Brittanica, which led him to make some original research work. In the article will be found a long account of steam thermometry, that is of thermometers where the indicating substance was to be the saturated vapors of different substances, water, sulphurous acid, etc., for he did not limit the term steam to water vapor. For some time every one in the laboratory was employed in making sulphurous acid, by heating copper in sulphuric acid in the usual way and condensing the gas in tubes immersed in freezing mixtures, and the atmosphere of the room was of a sort, which however noxious to germs of different kinds, was a little difficult to breathe.

One morning when all were thus occupied, an eminent chemist, who had just come home from the South for a vacation, called to pay his respects. After a word or two of inquiry as to how his young friend was prospering in his new post, Lord Kelvin said, "We are all very busy brewing liquid sulphurous acid for use in sulphurous acid steam thermometers. We want a large quantity of the liquid. Would you mind helping us?" So, requesting an assistant to find a flask and materials, he enrolled this new and excellent recruit on the spot, and what was intended to be a mere call, was prolonged into a long day of ungrudging work at an elementary chemical exercise.

In such a paper as this it is impossible to do anything like adequate justice to the life history of such a man as Lord Kelvin, but here are some figures which indicate something of the activities of the life:—

He wrote 25 books; delivered 661 speeches or papers before scientific societies; took out 71 patents; he received 25 honors from universities, 16 honors from governments, 88 honors from learned societies and academies.

But like all lives, great or small, useful or otherwise, the life of Lord Kelvin came to an end. He died in December, 1907, and at the request of the nation and practically all scientific men in the world, his remains were buried beside those of Sir Isaac Newton in Westminster Abbey.

Can there be any doubt that such as he, when he comes to restore his talents to his Lord who gave them, will hear the judgment, "Well

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done, thou good and faithful servant; enter thou into the joy of thy Lord."

Mr. La Rue Vredenburgh of the Edison Company of Boston, then talked on the subject of "Edison and the Practical Applications of Electricity in the Home."

After a brief introduction, in which he went over the historical development of electricity up to the time of Edison, Mr. Vredenburgh gave a very interesting outline of Edison's childhood and rise to prominence. He said in part:—

Edison was of Dutch parentage. His ancestors came to America in 1730 and settled in New Jersey, very near the spot where, 160 years later, Edison established his laboratory at Orange. His great-grandfather, as well as his grandfather, lived to be over 100 and his father died at 91 years of age. His early life history is interesting and amusing in many instances. When very young he became a newsboy, not through necessity, but to earn pocket money, with which to keep up a chemical laboratory in the cellar of his father's house. He had a passion for investigation, and wanted to prove things. At school he was pronounced a failure and sent home by his teacher as an addlepate. Getting hold of a dictionary of science, in which he found many startling statements made, he wanted to satisfy himself as to the truth of them. As a sample, one instance was where he had read that if sufficient gas could be put into anything, it would float in the air. He proceeded to verify this by giving a small Dutch boy two white Seidlitz powders, followed by two blue ones, with disastrous results both to the Dutch boy, and to himself afterwards.

He later was allowed to sell papers and magazines on a short branch railroad that plied back and forth between his town and the main road. Given an unused part of the baggage car, he set up a chemical laboratory there. One day a fire started through some upset phosphorus and he, together with his outfit, was summarily put off the train. He himself received a severe boxing of his ears from the conductor. To this boxing he today lays the deafness with which he was later afflicted.

During his life on the railroad, in and about the stations, he had picked up considerable knowledge of telegraphy and became quite skilful as an operator. There was a great demand for skilled operators all over the country at this time, and to this he now turned his attention, becoming a tramp operator, and thus travelling over a large part of the country in the South. He was sixteen years old, and kept at this for five years. Landing in Boston at this time, his first invention in the form of a vote recording machine, came out. It was not a success, not because of the device, but because the device, however perfect, was not wanted. In 1869 he went to New York, poor but ever alert, and secured a menial position in a house where

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quotations on gold were sent out. A clumsy machine was used for this; and one day it broke down, and no one seemed able to repair it. Edison here had his chance to show his keen observation, for he soon had it in order, and the consternation brought on by the failure to send out the quotations was quieted. His skill was recognized, and he was made superintendent of the plant at three hundred dollars a month. He became interested in the stock ticker, and made several improvements on it, taking out thirty-seven patents, among which were several valuable improvements. When it came to selling them, he was asked how much he would take. While pondering over the matter, while he thought he ought to get about five thousand dollars, he had about decided to sell for three thousand, when a bright idea come to him, and he asked the man how much he would give for them. When asked if forty thousand dollars would do, he said he thought it would. An amusing story is told concerning the payment of this, the first large sum of money he had ever received. Receiving a check for the forty thousand dollars, he went to the bank to cash it. When he presented it to the teller, the latter handed it back with some remark. Being hard of hearing, Edison thought the teller said it was no good. So he went back to the man from whom he had received it, much crestfallen over this sudden disappointment. His spirits arose, however, when he was told that all the teller had said was for him to endorse it. Returning to the bank, he was paid the money in small bills, which he proceeded to stuff into every available pocket. He sat up all that night guarding that money. Returning the next day to the purchaser of his patents, who had undoubtedly been back of the whole scheme of the small bills, he asked what he should do with it all. He was then shown how to start a bank account.

This forty thousand dollars was the start of Edison's real career, for with it he was able to carry out his dreams of a shop and place to make the many things that had been filling his mind. He established his shop in Newark, to manufacture stock tickers. At first he employed fifty men, soon increasing the number to one hundred and fifty. Inventions followed each other rapidly, many of which were not electrical. His shop grew with the increasing output. One of his first things was the carbon long distance telephone transmitter, a patent which he sold for one hundred and fifty thousand dollars. While Edison did not invent the telephone, he made long distance telephony possible.

The phonograph, the incandescent lamp, and the moving picture machine are purely Edison inventions. The former idea was worked out on paper first; and it was with great fear and trepidation that Edison, after reciting "Mary had a little lamb" into the tube placed on the rotating tin foil disc, reversed the disc, to be rewarded by hearing his own voice come back at him clear and sharp. This took place in 1878. The development and perfecting of it, however, did not

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take place at once, for at this point Edison's mind was taken up with the production of light by means of electricity. Scientists told him it was impossible. He believed it was possible, and, in his efforts to find the right substance for the filament, he tried six thousand different substances, all of which failed to work. By chance he tried a piece of bamboo taken from the edge of a palm leaf fan, and it worked. Thus the incandescent lamp was born. But here arose new problems. Where to secure this bamboo required travel and search. How to get apparatus that would give the proper exhaustion of the tube to keep the carbon from burning, required tedious experimenting. The details as to connections, fixtures, generators for producing current in sufficient quantity, all had to be worked out before the light was brought to its present day perfection. All of these were solved by the fertile brain of this wonderful genius.

His latest triumphs are the combined moving and talking picture machines.

Mr. Vredenburgh closed his talk with a number of slides showing the various types of electrical cooking and heating devices that are on the market, and those present were then given opportunity to examine samples of these which were displayed on a large table.

The meeting closed with a unanimous vote of thanks extended to Dr. Campbell and to Simmons College for their hospitality.

ALFRED M. BUTLER, *Secretary.*

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REPORT

OF THE SIXTY-SIXTH MEETING

OF THE

Eastern Association of Physics Teachers

At Boston University

Saturday, November 22d, 1913

A.J.W.

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REPORT OF THE SIXTY-SIXTH MEETING

OF THE

Eastern Association of Physics Teachers

at Boston University

Saturday, November 22, 1913

9.15 A. M.

Meeting of the Executive Committee.

9.30 A. M.

Business.

Reports of Standing Committees:—

On New Apparatus, George A. Cowen, Chairman.

Dr. Harvey N. Davis will give "A Demonstration of a Working Model of a Bridge Truss."

On Magazine Literature, Frederic H. Sawyer, Chairman.

On Current Events in Physics, George W. Day, Chairman.

On New Books, Ralph C. Bean, Chairman.

Election of New Members.

10.30 A. M.

"Some Experiments in Physics for Secondary School Teachers." Mr. Roswell Parish, Mechanic Arts High School, Boston (retired).

11.15 A. M.

Vice-President's Address,

"Applied Science of Pattern Making." William H. Timbie, Head of Physics Department, Wentworth Institute.

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Report of the Sixty-sixth Meeting.

The meeting was called to order by President Cowan, who first called for the

REPORT OF THE COMMITTEE ON MAGAZINE LITERATURE,

FREDERIC H. SAWYER, *Chairman.*

Scientific American. November 1. "What Are the Ten Greatest Inventions of Our Time?," by William I. Wyman.

November 8. "What Are the Ten Greatest Inventions of Our Time?," by George M. Dowe.

Scientific American Supplement. July 26. "The Principal Causes of Injury by Electricity."

August 30. "Installation and Care of Storage Batteries," by H. M. Nichols. "German Silver," by A. A. Somerville.

The Electric Journal. June. "Shop Testing of Electrical Apparatus. VI. Direct Current Generators. Additional and Special Tests. Three-Wire Direct-Current Generators.

July. "Shop Testing of Electrical Apparatus. VII. Direct-Current Motors, Shunt and Compound."

August. "Shop Testing of Electrical Apparatus. VIII. Industrial Series and Heavily Compounded Motors."

September. Shop Testing of Electrical Apparatus. IX. Direct-Current Railway Motors."

October. "Shop Testing of Electrical Apparatus. X. Single-Phase Railway Motors."

November. "Shop Testing of Electrical Apparatus XI. Alternating-Current Generators and Synchronous Motors."

Popular Electricity. June. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter III. Electrical and Magnetic Units.

July. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter IV. Materials Used by Practical Workers.

August. "Measuring the Flow of Streams," by Guy E. Mitchell. "How We Waste Our Coal," "Interesting Facts About Moving Pictures," by Charles E. Nixon. "The Making of a Half Tone." "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter V. Fundamental Laws and Equations.

September. "What Puts the Color in Kinemacolor?" "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter VI. Electrical Circuits.

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October. "Developments in the Industry of Liquid Air," by Dr. Alfred Gradenwitz. "What is the Aurora Borealis?," by Warren H. Miller. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter VII. Calculations of Wiring Line Losses, National Code.

November. "The 'Dream of the Ages' Fulfilled," by Carolyn Wilson Summers. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter VIII. Alternating Currents Simply Explained.

Electrical World. Vol. 62, No. 18, p. 898. "Testing Shunt Instrument Transformers." Vol. 62, No. 16, p. 793. "Carbon and Impregnated Electrodes for Arc Lamps." Vol. 62, No. 16, p. 798, "The Nitrogen-Filled High Efficiency Tungsten Lamp." Vol. 62, No. 9, p. 425, "Wireless and Weather." Vol. 62, No. 4, p. 181, "Water Sterilization by Ultra Violet Rays." Vol, 62, No. 1, p. 29; Vol. No. 2, p. 75; Vol. 62, No. 3, p. 132, "Phase Compensation."

Harper's Monthly. June 1913, p. 112, "Exploring the Atom." July, 1913, p. 229, "Cold Light." August, 1913, p. 363, "Atoms."

School Science and Mathematics. Vol. 13, No. 6, p. 461, "Realness in Science Teaching." Vol. 13, No. 6, p. 469, "The Negation of Perpetual Motion in Elementary Physics." Vol. 13, No. 6, p. 483, "High School Physics in the State of Indiana." Vol. 13, No. 6, p. 492, "Oscillations from the Electric Arc." Vol. 13, No. 6, p. 501, "The Joint Committee on Physics." Vol. 13, No. 7, p. 577, "Gas and Electric Furnaces for Physics Laboratory Work." Vol. 13, No. 8, p. 655, "Demonstration of the Magnetic Field of a Dynamo and the Effect of Armature Current on This Field." Vol. 13, No. 8, p. 669, "The Heat of Fusion of Tin."

This was followed by the

REPORT OF THE COMMITTEE ON CURRENT EVENTS IN PHYSICS, GEORGE W. DAY, *Chairman.*

ELECTRIC POWER PLANT FOR THE CANAL ZONE.

The *Boston Evening Transcript* of August 27 contains an interesting description of the immense electric plant—the greatest in the world—which is to be installed in the Panama Canal Zone. At the Gatun Spillway a portion of the lake water will be passed through powerful turbines, and electrical energy will be generated at 2200 volts, 25 cycles, and 3 phase, and conducted to a transformer substation, where the energy will be transformed from 2200 to 44,000 volts. Thence it will be conducted to three load centers—at Miraflores, Balboa and Cristobal—completely across the Isthmus.

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Continuity, the Atomistic Trend of Modern Research.

The address of the President, Sir Oliver Lodge, before the British Association, on "Continuity, the Atomistic Trend of Modern Research," and a "Plea for Conservatism" has attracted public attention, not only because of its remarkable survey of the progress of modern science, but because of its deliberate and emphatic assertion of the continuity of personal experience and of personality after death. The full text of the address is given in the issues of the *Scientific American Supplement* for September 20 and 27. It is worthy of a careful reading.

Removal of Gamboa Dike.

On October 10 the dike that separated the waters of Gatun Lake from Culebra Cut was partially removed by the explosion of forty tons of dynamite, through the agency of an electric current set into operation by President Wilson. This explosion removed the last great obstruction of the Canal, and when the dredging of what remains of the dike, and of the material of the Cucuracha Slide seven miles nearer the Pacific, is completed, there will be a passage for vessels of the construction type from ocean to ocean.

Powerful Radio Station at Panama.

The Navy Department is to construct a large naval radio station at Carmiento, to be called the Darien Radio Station. It will have the same power as the one at Arlington. The three towers will be 600 feet high and the bases will be 180 feet above sea-level. The sending and receiving radius will be about 3000 miles. It will cover a vessel anywhere on the east coast of the United States, and reach St. Vincent, 500 miles west of the coast of Africa, besides San Francisco and the lower western coast of South America. For sending, the Poulsen wireless apparatus will be used.

An article in the *Scientific American* for November 15 tells of the experiments of the Wisconsin Geological and Natural History Survey to determine the rate at which the energy of the sun's rays is absorbed as they pass into the waters of lakes. It appears that not more than one per cent. of the energy at the surface reaches a depth of five meters, and at a depth of one meter there remains not more than twenty per cent., and sometimes there may be as little as two per cent., according to the purity of the water.

In *Science* for August 29 is an article telling about experiments made in Michigan to determine the cause of local magnetic storms. It is claimed that the particles of air ionized by solar radiation set themselves along lines of force so as to add their magnetic effect to the earth's magnetic field. The magnetic permeability of the air is lessened by shadows, wind and rain.

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The *Scientific American Supplement* for July 12 quotes from Dr. Nordman's article on applications of cold. He discusses the important consequence of the cheap production of oxygen and nitrogen by liquefying only the oxygen part of the air—a method devised by M. Claude.

At the Congress of Refrigeration which met at Toulouse recently the term *frigorie* was adopted. Its meaning is the inverse of that of the calorie.

Popular Mechanics, October 13:—

A non-stop aeroplane record of 287 miles in 265 minutes has been made by C. Marvin Nord, at Long Island.

The latest movie craze utilizes the moving film in a motion picture shooting galley.

The Darien wireless station has a record of receiving and sending 3000 miles.

The tallest chimney in the world is said to be located at Great Falls, Montana—506 feet high.

For the Committee on New Books, Ralph C. Bean, Chairman, Mr. Boylston reviewed

PRACTICAL PHYSICS (Davis and Black).

This is the most recent of any physics I know of, and in these times the latest authors of science books have a distinct advantage over all previous ones—for they are "heirs of all the ages, foremost in the files of time" if they are men like our Henry Black and Harvey Davis. The title is Practical Physics for Secondary Schools, by N. Henry Black, Science Master, Roxbury Latin School, and Harvey Davis, Assistant Professor of Physics, Harvard College. pp. 487, 465 cuts and illustrations. Published by MacMillan Company. Price, $1.25.

The frontispiece is a full-page portrait of Galileo. The preface is full of excellent suggestions concerning the teaching of physics and is a valuable part of the book.

The subject matter throughout is taken up in a most practical and common sense way, and constantly connected with everyday affairs, so that the name Practical Physics is entirely appropriate. One who has taught physics year after year naturally looks at every new book to see in what order the author has taken up the various topics, and the wonder is that so many authors make a mess of this important feature. According to my conception of what is rational and correct, Black and Davis' book presents the topics in the right order. Each teacher, of course, may take up the topics in any order he chooses from whatever book he has, but unless that order conforms pretty nearly to the one in the book, he is all the time running into problems and discussions that the pupil is not prepared for.

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Here is a book where that feature has evidently been carefully considered. Beginning with the simplest and easiest topics—Simple Machines, Mechanics of Liquids, Mechanics of Gases, Non-parallel Forces, Elasticity and Strength of Materials—they are then ready for the more severe tests of their physical instincts (if they have any) in dealing with Accelerated Motion, Force and Accelèration, Energy and Momentum. These subjects are deferred to page 133 and then taken up and carried through 37 pages of most fascinating and instructive discussion, demonstration and illustrative application, interspersed with plenty of problems to test the understanding.

Those of us who were present at the Brookline meeting a year ago heard Dr. Davis' talk on "New Methods of Treating Some Old Mechanical Problems." To my mind that was one of the most valuable and suggestive contributions we have ever had in our long list of excellent lectures and discussions. We have those excellent methods of treating these topics embodied in this book. Heat comes in at the right time of year to have snow and ice to use, and then Electricity follows, and Sound and Light.

There are nineteen pages on heat engines, nine pages of which relate to the steam engine and two pages to steam turbines.

The summary of principles at the end of each chapter and the questions and problems that are interspersed at proper intervals all the way through are unusually good and well arranged. Besides the portrait of Galileo there are scattered through the book portraits of Pascal, Newton, Joseph Henry, Faraday, and Helmholtz.

A Laboratory Manual accompanies the book and contains excellent directions and illustrations for fifty experiments. The typography and binding of both books are up to the MacMillan standard.

Altogether Practical Physics is a splendid book, and merits wide adoption as a text-book of Physics in secondary schools.

The publishers have issued a more detailed demonstration of its excellent points in the form of a little pamphlet, "Strong Points of Practical Physics.

Mr. Bean then reviewed

ESSENTIALS OF PHYSICS (Hoadley).

Hoadley's "Brief Course in Physics," which came out in 1901, has now been revised and sent out under a new title, "Essentials of Physics." A comparison of the two shows that there has been a real revision as well as an increase in the number of pages. The newer book has 536 pages, as against 463 in the older. The divisions are as follows: Mechanics 190 pages, Sound 46, Heat 63, Magnetism and Electricity 135, and Light 84. The type has been improved and the lines do not appear so crowded. The diagrams and illustrations are clear and for the most part well chosen.

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The material of the text seems to be in line with what we believe a modern text should contain. The book practically begins with a discussion of the properties of matter, such as impenetrability, porosity, etc. This method might be open to criticism as it would seem to me to be confusing for the student to meet this so early. The laws of freely falling bodies are also treated rather early.

There are many parts of the Mechanics which are very commendable. We find the centrifugal drying machine used to illustrate centrifugal force and a diagram. A pile driver is shown as an introduction to Energy. The locks of the Panama Canal are shown and the hydraulic ram. Among the uses of the air pump is given the manufacture of incandescent lamps and thermos bottles. The Zeppelin air ship and an aeroplane are shown. The barograph is shown and described and the weather map is taken up to some extent.

The introduction to the study of Sound by a discussion of simple harmonic motion is a little in advance of some of us. The whole treatment of Sound goes much farther into detail than the most of us could hope to go.

Under Heat the British thermal unit is taken up. The turbine and gas engine receive a place. I notice that the thermos bottle and clinical thermometer are illustrated and described. Magnetism and Electricity and Light seem to me to be well written. I was interested to note the use of the optical disk in illustrating the various principles in light.

The last chapter, "Invisible Radiations," attracts your attention. Here we find treated wireless telegraphy, cathode rays, x-rays, radioactive substances, and to a very slight extent ionization.

This was followed by a review of

ELEMENTS OF PHYSICS (Crew and Jones).

This is a book of 435 pages, divided as follows: Mechanics 163 pages, Sound 31, Heat 49, Magnetism and Electricity 87, and Light 58.

The authors do not believe in physics as a series of disconnected subjects but as a harmonious whole. The introduction gives a hint as to the plan followed: "The purpose of the study of physics is quite as much to furnish the student with a logical and easily remembered arrangement of his present knowledge as to put him in possession of new facts." The body of the text is carefully subdivided, and the way in which a given subject is to be divided is stated beforehand, so that the pupil has before him an outline of the work. Also at the end of special subjects there is a summary of the facts given. This takes the form of short positive statements.

After a chapter on Motion, the general properties of matter are

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treated under the following heads: (1) Inertia, (2) Gravitation, (3) Energy, (4) Elasticity. Then follows the properties of liquids and of gases. As a transition from the subject of Mechanics to that of Sound and Heat, a chapter on Waves is introduced.

New words and important headings, as well as important conclusions, are printed in black face type. It serves the purpose of emphasizing the more important subjects.

There is a good selection of questions and problems scattered through the text. In addition, at the end there are 34 pages of questions for review gathered from examination papers. Also at the very end are solutions of some of the common types of numerical problems. I might add here that the insides of the covers are filled with the Metric System and other tables.

The practical application of physical principles to various machines and instruments is not followed out to any great extent. Many of these which we find in the ordinary text, are left out altogether. On the other hand, the book is up to date in what it does give. The authors state that much time is saved by their method and that the teacher is given a greater freedom.

For the

NEW APPARATUS COMMITTEE,

GEORGE A. COWEN, *Chairman*,

Mr. Packard showed two simple pieces of apparatus to show linear expansion of brass. The expanding brass consisted of the tube used in the Cowen Linear Expansion apparatus. One end was securely fastened to the swivel post attachment of the Harcourt universal T beam basic clamp A. The other end passed through another swivel attachment, but was free to move back and forth. The free end rested against the shorter end of a lever pointer. This pointer was screwed to a section of a meter stick, so that the short and long arms could be easily read. The expansion of the bar when steam passes through can thus be shown and calculated.

The other form used the same brass tube. One end was securely fastened to a binding post. Near the other end was a hole through the tube. Through this hole was passed a pin on a section of meter stick. The end of this section nearer the pin was screwed to a fixed support. At the long arm end was a scale by which expansion could be shown. The difference in the action of the two lay in the fact that in the first a first-class lever was used as indicator, while in the second a third-class lever was the form.

Dr. Harvey N. Davis then gave a most interesting and instructive demonstration of the action of a bridge truss.

By way of introduction Dr. Davis said he knew of no better example of the practical application of the parallelogram of forces than in the truss so common in bridges and roofs.

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Bridges may be divided into three classes: *arched bridges* of *masonry* or *steel*, *girder bridges* and *trussed bridges*. Of these the girder bridge is carried by its own *stiffness*. Trussed bridges, however, are made up of separate members, each one of which must resist a *push* or a *pull*. There is no direct bending force on any one member. The members are assembled in triangles, the truss being composed of a combination of triangles.

Of trussed bridges there are two types, known as *riveted* and *pinned trusses*. In the *riveted* type there are gusset plates at the points where the members come together. These plates are like the web between a duck's toes, and the members are riveted to them. In the *pinned* type, a pin holds the members together by running successively through holes at the ends of the members. In both the riveted and pinned types the holes for either rivets or pins must be very carefully made, so that the alignment may be correct.

Most small bridges are riveted. They are stiffer, and have less shake or give.

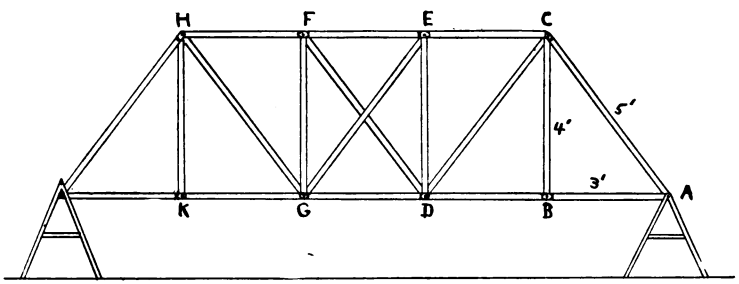

FIG. 1.

Large bridges in America are mostly pinned. In England they are riveted. The pinned type is more quickly set up, and thus saves time on the job. This is because most of the work can be done in the shop, before the members are shipped, and the only thing left to be done is to drive the pins through the holes.

Whether of the riveted or pinned type, bridges are designed in exactly the same way, namely, as if they were pinned. The gusset plates are then regarded as increasing the factor of safety. In riveted bridges, however, especial care must be taken to bring the members into exact alignment, or the actual stresses may be very different from those expected.

The members of a truss are either *compression* or *tension* members, and the two kinds are very different in appearance. The tension members are steel straps or bands, while the compression members are much larger, and are latticed, so as to avoid buckling.

The reason that there are both compression and tension members can be shown by the following computation: If in the figure (Fig. 1)

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the bridge itself weighs 50 pounds and at the points K and G weights of 50 pounds are placed, with the left hand support used as an axis, there will be positive moments of $50 \times 3 = 150$; $50 \times 6 = 300$; and $50 \times 7.5 = 375$. This totals to 825. The negative moment is produced by the upward force of the right hand support, through an arm of 15 feet. This force is thus 55 pounds. Now since the support is pushing up with a force of 55 pounds, this end of the truss is pushing down with a force of 55 pounds. This 55-pound force may be resolved into a push CA and a pull AB. AB will be three-fourths of 55, or 41 pounds, and CA will be a push of five-fourths of 55, or 69 pounds. Thus AB is tension and CA is compression. This may be proved by placing hooks on the transverse pins holding the front

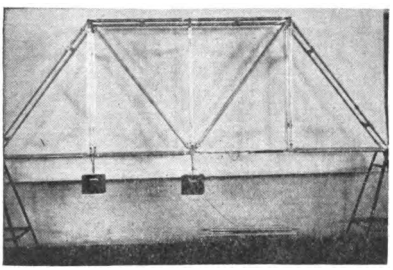

FIG. 2.

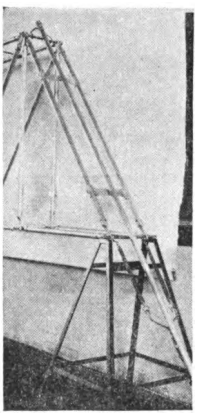

FIG. 3.

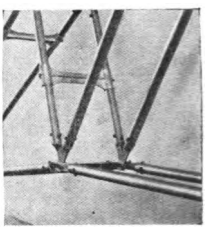

FIG. 4.

and back of the truss together through A and B, and connecting them by a turnbuckle through a spring balance (Fig. 2). When the pull on the balance reaches 41 pounds, the members AB at front and back may be removed and the truss holds firm. The member AB is thus pulling just as hard on pin A as on pin B. In like manner by placing between pins A and C an arrangement with balance and turnbuckle to pull A and C apart (Fig. 3), the members AC at front and back may be rattled when the balance indicates 69 pounds. In a similar manner the tension or compression in any member may be calculated and tested.

The action of the diagonal members DC and GH may be shown by removing one of them, say GH, and supporting the truss by hand. The tendency will be for the member FG to *fall* and the member HK to *rise;* that is, the tendency will be for the distance HG to lengthen and for the distance FK to shorten. The presence

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of a member along *either* diagonal of this panel will hold the truss rigid, but evidently, if the member runs from H to G, it will act in tension, while if it runs from F to K it will act in compression. In steel bridges the diagonals are almost always so set as to act in tension.

The reason for the two diagonal members GE and FD is that when the weight is at G, GE is in tension and FD is slack, while the condition is reversed when the weight is at D. If there had been only one diagonal in this panel, it would have had to resist compression under some loads, and tension under others, and so would have had to be designed as a compression member. Two are provided, because two tension members are cheaper than one compression member.

The difference between the two types of trusses, called the Howe and the Pratt, lies in the fact that in the former, the diagonals are compression members, while in the latter the diagonals are tension members. The former is thus a heavier type of bridge, and the diagonals run the opposite way, *i.e.* from K to F and from E to B.

In closing his demonstration, Dr. Davis showed several slides of different forms of trusses set up with his members, and then described the members themselves. They are three, four, and five feet in length, and are made of aluminum tubes 1¼ inches in diameter. Into the ends of these fit aluminum castings turned to size and held firmly in place by bolts. (Fig. 4.) These end castings are flattened so as to fit snugly together on the pin which passes through a hole in the flat end. These members should always be placed on the pin in such an order as to bring the main strains adjacent and thus cut down the leverage between them. Otherwise the pins are likely to bend.*

On the recommendation of the Executive Committee the following were unanimously elected to membership:—

ACTIVE:—

R. M. Frye, Boston University, Boston, Mass.

B. T. Leland, Technical High School, Providence, R. I.

ASSOCIATE:—

A. A. Gustafson, Wilbraham Academy, Wilbraham, Mass.

Mr. Roswell Parish then described several pieces of home-made apparatus, and gave a number of experiments which he had occasionally employed with classes to emphasize the importance of the parallelogram of motions, and to show its use in the study of ether vibrations and certain color phenomena. The elliptical motion of

* A more extended treatment of this truss will appear later in *School Science and Mathematics.*

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the particle in a water wave was resolved into vertical and horizontal components, and attention was directed to the possible agency of each component in producing a similar motion of like particles within an obstruction, such as a slatted structure like a picket fence with the slats in a vertical and in a horizontal position. By means of a polariscope with two bundles of glass plates and a large lens mounted on a stand for projection, it was shown that no light passes when the polarizer and analyzer are crossed, that there is therefore no forward or longitudinal component of the vibratory motion, in other words that the vibrations are entirely transverse.

After a brief explanation of what polarization of light means and the different kinds, a wire model was used to show the possibility of double refraction and the degree of separation of the rays in a uniaxial crystal. It consists of a circle and an ellipse fixed at right angles, pivoted to revolve about the major axis, and having the respective wire diameters through the common center always normal to each other so as to indicate by their lengths in different positions the facility of vibrations in their respective directions and therefore the speed of their corresponding rays.

In the next experiment, a doubly refracting half-wave mica plate was placed between the polarizer and analyzer in such a position that the original vertical vibrations of red light were entirely suppressed and the bright image appeared upon the screen when the analyzer was turned to transmit horizontal vibrations only. By means of diagrams the conditions of vibrations at successive points were indicated, and also the resolutions and recompositions effected at the refracting surfaces, both for red light and for colors corresponding to a different wave-length. It was then shown that whatever vibratory motion was suppressed in one direction was reproduced in the direction normal to it. Therefore when white light was used, the colors corresponding to the two sets of vibrations were found to be complementary. This was more clearly seen when the double images produced by Iceland spar as a polarizer were projected, the overlap of the images showing white upon the screen. Several interesting illustrations were then given with plates differing in material and thickness.

Mr. William H. Timbie delivered the Vice President's annual address on:—

Applied Science of Pattern Making.

There are certain time-honored customs which a man living in Boston must recognize as always having taken place, and which he must expect always will continue to take place. He must expect to eat beans every Saturday night. He must expect to eat fish balls every Sunday morning, and so on and so on. But before we get to

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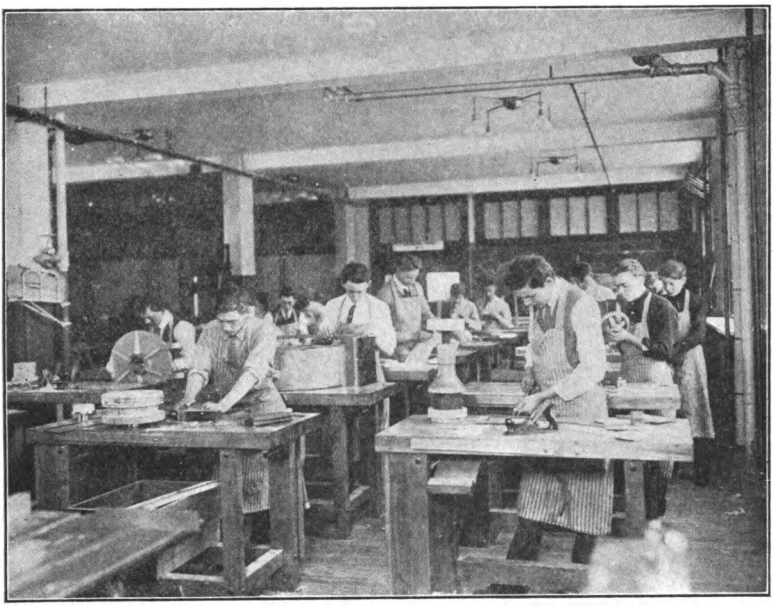
the "world without end" part, we must mention that every fall the Eastern Association of Physics Teachers must have a vice-president's address.

The only vice-president's address I ever had the pleasure of listening to, I heard last fall. It was a calm, dignified, philosophical discussion of "The Duties and Opportunities of Physics Teachers."

Now this vice-president's address has got to come off this year as usual, in spite of the fact that I'm not much on the "philosophical stuff." But I'll try to work all the philosophy I know into the topic assigned me, "Applied Science of Pattern Making."



A CLASS OF PATTERN MAKERS AT WORK.

The first place where there seems to be a chance at bringing in this philosophy is in the reason why we teach science at all to pattern makers.

After centuries of conscientious and self-sacrificing work on the part of generations of school teachers (school teachers are always conscientious and self-sacrificing when they are writing about themselves), a system of education was developed which gave a magnificent training to the minds of the youth, more especially to that part of their minds closely connected with their memory. Then arose the cry of "Every boy should go to college." So every boy tried to

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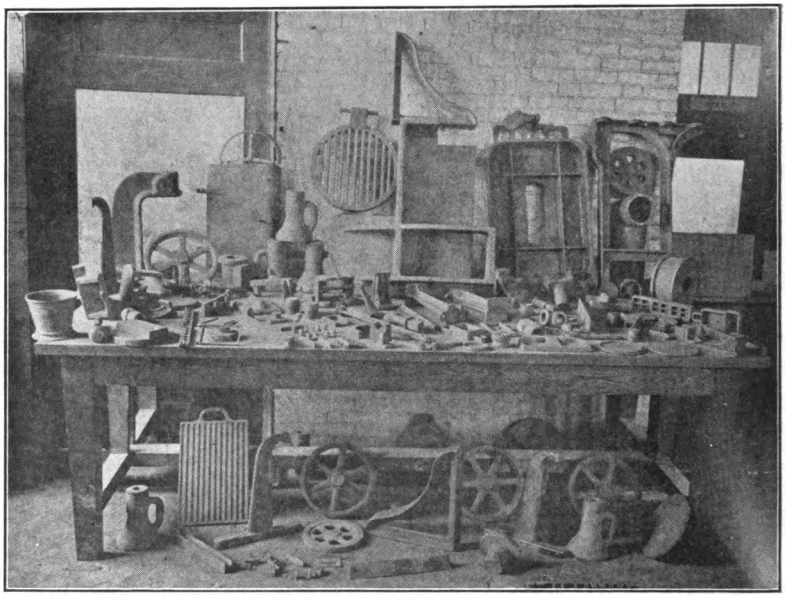
get prepared and there was a great rush of boys to preparatory schools and academies. Then came the most astonishing discovery of the present age, that all boys' minds are not exactly the same. Some of the minds which were presented for this training didn't seem to fit the system. "There must be something the matter with their minds," said the various intellectual boards of examiners, as they went through the routine of inspecting these specimens. "If this system of education doesn't fit them, they aren't worth training." So they sent the boys who possessed this kind of misfit minds away from school. Deprived of the advantages of this educational system, these poor chaps grew up into such very ordinary men as



A FEW OF THE CASTINGS FOR WHICH THE PATTERN MAKERS MADE THE PATTERNS.

Eugene Field, who was requested to withdraw from Williams, or James Fenimore Cooper, who was dropped from Yale.

But kind-hearted persons began to feel sorry for these boys with such weak minds. "If their minds are no good, let's educate their hands," they said, and so the trade schools were founded, where the boys' hands went to school. But the boys didn't flock to these. They seemed un-American. They didn't give a boy much of a chance to rise above his first position.

So gradually there developed the modern idea in education that

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the ideal school is not that institution which educates any particular part of a boy to the neglect of the other parts, but that institution where the whole boy goes to school.

Accordingly, philosophical point No. 1,—the training of the pattern maker's eye and hand takes place in the shop. The applied science laboratories and recitation rooms are needed for the training of his mind.

Further, since boys' minds differ, the training which suits one will not suit the other. The careful and precise measurements of the machinist's science course would be out of place in the course laid out for plumbers. Thus there must be almost as many kinds of science courses as there are kinds of minds.

Philosophical point No. 2, therefore, is: Fit the science course to the kind of mind which the student possesses.

Thirdly and lastly for this philosophical talk.—We believe that instead of filling the student up with theory while he is at school, and waiting for him to get his practice when he gets out, hoping that he will somehow be able to see the connection between the theory we taught him and the job he is set to do, years after the instruction; instead of doing this, we endeavor to tie the theory to the job, by having him do the job and learn the theory at the same time. This limits our theoretical science to that part which is most closely connected with his shop work and his work at his future calling.

Thus to sum up:—

1. Along with the shop work a liberal amount of science is taught in order to educate all the boy's faculties and enable him to advance in his chosen work.

2. This science is of a certain kind fitted to the kind of mind his calling demands in order to attain the greatest success.

3. Only those parts of science are taught which are intimately connected with the materials and processes of his trade.

With the class in pattern making we started with levers and the principle of moments. The class was given the following problem:—

A 200-pound motor is hung from a beam at a point two feet from one support and eight feet from the other. Compute the pressure on supports A and B.

We use a 200-pound motor and a ten foot beam because we have these pieces of apparatus in the laboratory. After the class has computed this problem, the motor is set on a beam, the ends of which are supported on platform scales, and the pupil checks his computation. He is then asked to compute the pressure on end A, if a support C is put in. Not many get this problem correct, and the student who does and finds that the pressure at A becomes much less, is loath to believe it. So each tries it on the platform scales and corrects or verifies his result. It is now that the general law

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of moments is introduced. About two weeks are spent in working out in the class-room and laboratory such problems as the pressure of lathe tools on tool rests, when different kinds of wood are turned, different speeds are used, and with the rest placed at different distances from the work.

We have installed a two-ton floor crane. And computations and tests are made of the pressure on the wheels for different loads. As the crane itself weighs 800 pounds, it commands the boys' respect and they work hard at it. And anything at which boys work hard, you may be sure they learn. It is of the utmost importance that these men know the principle of moments, as will be seen from a later part of their course. All sorts of levers, with which they are familiar in the shop are studied, such as claw hammers, pliers, bit-braces, screw-drivers, wrenches, jack screws and hand clamps. I'm afraid that resolution and composition of forces with the parallelogram law is rather neglected with these men, although that is the main part of the first term's work of the carpenters and builders, with their thousand and one forms of roof trusses.

The pulley is now introduced as a form of lever, and the opportunity for a lesson on safe rim speeds, safe belt speed is made the most of. The student makes a test on a simple cone pulley arrangement in order to determine the velocity ratio of the shafts. Then he is given a speed lathe, with the usual cone pulley attached. He is assigned the job of getting the spindle to run at a definite speed, being furnished with a motor of known speed, and pulleys of a variety of sizes to fit the motor or the counter shaft. He is given no electric power until he reports to the instructor that his set-up is complete and that he believes the lathe will operate at the desired speed. When the instructor throws on the power, do you think this boy loses many minutes until he has found out how near the correct speed his set up comes?

Similarly he works with simple spur gears, and then is given a mounted commercial gear box with thirty changes of speed, and required to set it for a definite shaft speed. This is tested like the lathe.

The step to the efficiency of the different drives is a very short one bringing in the ideas of *work*, *power* and *energy*, all of which are studied directly from the machines in the shops and laboratory. Efficiency and service tests are also run on the larger machines in the pattern shop, so that the student not only gets a concrete idea of the working of each separate part of a machine, but he also learns the relation of each part to the others, and to the whole machine. And all the time he is learning the meaning of force, torque, work, power and efficiency, not from some carefully worded definition, but from living with these things and becoming acquainted with them.

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You have no idea how interested these boys get in studying belts,—proper widths, proper thicknesses, proper speed, and tensions, slippage, dressing, etc.—provided they study it with life-size belts and commercial installations. And it's all nothing but studying the principles of applied physics of such subjects as force, friction, elasticity, work and power. Most of these boys do not know that there are formulas for most of the relations studied; as for instance, the width of a belt and the horse power transmitted at a given speed, and they are more than happy to find themselves able to "dope it out," as they call it. Those who have heard of these formulas are equally pleased and surprised to learn that there is a simple reason for most of the formulas,—that they are not weird combinations of figures that some magician has learned to conjure with.

Because the pattern maker works in a shop filled with machines, and because he works on patterns of parts which are to be built into machines, we believe that all this study of machinery is necessary, and it surely seems to be interesting to him. Likewise because his trade is closely connected with the foundry, we teach him much of the general science pertaining to the foundry. For instance, he is told in the shop that to find the weight of a cast iron casting made from a white pine pattern, he has merely to weigh the pattern and multiply by 16.7. We show him that this is merely the ratio between the specific gravity of cast iron and white pine, by having him weigh a block of pine and a block of cast iron of equal size. The weight of an equal volume of water is found by weighing an equal volume. The specific gravity and weight per cubic inch of the different woods and metals are found, and constants are worked out for computing the weights of castings of various metals from the weight of the patterns.

Archimedes' principle is a most important part of the knowledge they should acquire here. But they are not so much interested in the buoyancy of water as of molten iron, molten brass, etc. So we go them one better and study the buoyancy force of mercury exerted on a cube of core sand.

An iron tank is partially filled with mercury and measurements are taken of the pull which is required to draw the cube down to different depths in it. The main object is to show the pupils that the buoyancy force reaches a maximum the instant the object is immersed, and that pulling it further down into the fluid does not increase this force. From data and principles derived from this experiment, the students compute the force necessary to anchor a core of a certain size in moulds of given shapes.

The pressure which the molten metal will exert on the top of the flask should also be made an easy matter of computation for pattern makers. They should know something of the difficulties met with by the foundrymen when a casting of considerable depth

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is to be made. They should be able to compute the weight that must be piled on top of the flask in order to keep the cope from being forced off by the pressure of the metal. Accordingly, we have designed some molds of plaster of Paris. The molten metal which we use in these is, of course, mercury. These plaster of Paris molds are built with the same area but with risers of different heights. The effect of the height of the riser is then studied by pouring mercury into the mold and noting the weight that must be piled upon the cope to keep the flask from separating. From these experiments the student learns the advantage of designing a split pattern so that the upper part has as little depth as possible.

The reason is now taken up for the pattern maker's rule being longer than the ordinary rule by the amount which molten metal will shrink on cooling. This is studied by means of a device which was designed at the Institute. The usual flask and mold are used. Strips of steel are introduced into the ends which will be drawn in as the metal contracts. The behavior of different metals upon cooling is noted, and the amount of the expansion and contraction is measured.

The electricity which the pattern maker gets consists largely of the ideas of current, pressure and resistance. In this he makes free use of the voltmeter which he treats as a pressure gauge, and the ammeter, which he learns is a flow-meter. Resistance is always computed from the reading of voltmeter and ammeter. The laboratory work starts with wiring up lamps with switching points located at stated places. This gives him the idea of polarity, or the two-sidedness of a circuit. Then follow simple experiments with the current and resistance and voltage effects when lamps, motors and other electrical devices are put across the circuit on different combinations.

Electric power is taken up by testing the brake horse power of motors. From now on the student always has to wire up his own motor and starting box, whenever he wishes to use electric drive. You may be sure he has all the common kinds of motors and starting boxes to work with before he is through.

For the fill-in work, in order to keep a diversity of work running at the same time in the laboratory and to avoid the interest-killing effect of having all the pupils doing the same thing at once, we keep running such experiments as:—

1. The effect on a joint of sizing the pieces before gluing them. Two blocks of wood are glued as carefully as possible, but without being sized with glue. The strength of these to withstand tension is tested. Then two pieces of exactly the same cross-section era and material are sized with glue and allowed to stand a day, then sandpapered and glued together. The students are much surprised to

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find how many times the greater load the sized joint will stand than the unsized.

2. The strength of different glued points. Butt joints are glued and tested; next a lap joint and then a mortise joint, and finally a box joint. Of course, tests of these methods of manufacture do not afford definite quantitative results, but rather general information as to the type of work which requires the different kind of joints.

3. The holding force of nails and screws.

4. The effect of making patterns in strips, rather than of solid pieces of wood;

(*a*) As to strength.

(*b*) As to warping.

5. Effect on the strength of cores of using different core-binders or of baking the cores for different lengths of time.

The foregoing work occupies about one-third of the time allotted to science and, it will be noted, includes a pretty stiff course in mechanics of solids and fluids, the emphasis being placed on the principle of moments and the study of machinery. This affords the ground work for what we consider the main object of his science work, namely to give the pattern maker an accurate sense of correct proportion and economical distribution of material in his patterns. Although he works almost entirely in wood, the ultimate product of his labor is a casting of some metal or other. Therefore we do not spend much time upon the strength of wood and the shapes into which it can be carved, but rather the strength of cast iron, bronze and aluminum and the shapes into which these metals can be poured.

We study, accordingly, the effect of the length of a beam upon its strength, by casting a large number of beams of different lengths but with the same cross-section, and then breaking them in the testing machine. A few of these same beams are tested for the deflection under different loads in order to learn the relation between stiffness and strength.

These experiments are repeated with such metals as cast iron, cast steel, cast bronze and cast aluminum. In order to learn the effect of depth upon the strength of the beam, castings are now made of beams which have the same length, but which vary in depth. These are tested both for strength and stiffness just as the first lot were. Similarly, the effect of width upon stiffness and upon strength of beams is studied.

To find out how well the students are able to apply the principles which they have been studying, the following problem is given them: They are told to bring into the class-room the pattern of a beam which they think will stand the greatest load. The beam must be 24 inches long and of two inches cross-section. The patterns are

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first brought into the class-room and measured, to be sure that none of them has exceeded the cross-section allowance. They are discussed by the class and the instructor and estimates made upon which beam will hold the most. The foundry now casts up beams from these patterns, and a very interesting session takes place in the testing-room when the boys break them. You may be sure that excitement runs high as each piece is put into the machine. The boy who has made the strongest beam is not likely to forget the principle upon which he worked. As to the others, the fact that they were mistaken in their design, is nearly as good a goad to their memory.

The great difference between the tensile strength and the compressive strength of cast iron is studied by breaking large specimens under tension and under compression. This enables the boys to apportion the amount of cast iron correctly in patterns so that the part that is to be under tension shall be of large cross-section compared to the part under compression.

How well these principles have been learned by the pupils is determined by a class exercise similar to the one for the beams. The boys are told to bring in a pattern of a bracket which will weigh, when cast in iron, 20 pounds. This bracket has to stand a weight of 1000 pounds at a distance of two feet from the support to which it is to be fastened. When the patterns are all handed in to the instructor, they are taken into the class-room. The good and bad features of each are here pointed out and discussed while each boy is still confident that his design is the strongest. As in the case of the beams, these brackets are broken in the test room, and the lessons and principles in distribution of material are again pointed out.

One of the hardest things for a pattern maker to understand, is the big effect which the mere putting in of a fillet has upon the strength of a cast iron structure. Accordingly, a number of patterns are constructed and castings made from them, in which the corners are all square. These are tested in the machine and compared with the strength of other lots of castings in which the corners are all rounded out with fillets of different radii. The difference in strength between straight line and curve construction is studied and tested in the same way. Similarly, the strength of rounded domes is compared with the strength of box-like or square structures. The idea is not so much to enable a student to sit down and calculate by means of "moment of inertia," "neutral axes" and "radii of gyration," but to give him a proper sense of proportion,—almost an intuition for the correct distribution of material, in order to insure the strongest possible device for the least possible metal. Of course, he does make very careful mathematical determinations for the expected maximum load in all these

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instances, but the greatest emphasis is laid upon his experience in the testing-room rather than upon his computations. In practical experience the pattern maker has hitherto been obliged to acquire this sense of proportion by very expensive experience. For instance, he would construct a pattern, and if it stood the stress that it was expected to, he would be sure that he could construct another one along the same general lines to hold the same load. But if the casting made from a pattern was found to be weak in any place, he was informed of this by the engineer, when a corrected blue print came through to replace the old one. Through experience of this kind he gradually learned just that sort of information which we are trying to give to these boys in a much less expensive and more logical way.

A unanimous vote of thanks was extended to Boston University for their hospitality in receiving the Association.

At the smoker, held at the City Club on Friday evening, Mr. N. Henry Black entertained about twenty members of the Association with a most entertaining talk on his impressions of two of the physics teachers and laboratories he visited in Germany. The two schools in which these were located were the Oberrealschule of Hamburg, where Professor Grimsehl, honorary member of our Association, is instructor; and the Realgymnasium of Berlin, where Professor Hahn, also an honorary member, is instructor. By both of these men he was most cordially received, and fully introduced to the laboratory and lecture systems there used, as well as made acquainted with pupils. He was enabled to make many slides of the lecture rooms, laboratories, shops and store rooms of the two interesting men, and was thus able to give a very clear idea of their place of instruction as compared with ours here in America. He found that pretty nearly the same problems must be met in Germany as confront us here. There are good, bad and indifferent pupils. However, there is far less tendency to make light of the work.

In the lecture room a decided difference lay in the fact that there was a space of about fifteen feet between the front wall of the room and the lecture table. This allowed of bringing large pieces of apparatus into the lecture-room, and left plenty of room for the pupils to group about it.

Three facts stood out in his mind as a result of his observations:—

1. There is more money being spent in preparing the teachers for their work than here. Less is put into schools and equipment.
2. The lecture apparatus is better, and there is more of it. There is not so much put into the laboratory apparatus.
3. There are better storage facilities for apparatus.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SIXTY-SEVENTH MEETING

OF THE

Eastern Association of Physics Teachers

at the High School of Practical Arts, Roxbury, Mass.

Saturday, March 7, 1914

Morning Session

9.30 A. M.
Meeting of Executive Committee.

10.00 A. M.
Business.
Annual Report of the Secretary.
Annual Report of the Treasurer.
Reports of Standing Committees:
On Magazine Literature. Frederic H. Sawyer, Chairman.
On Current Events in Physics. George W. Day, Chairman.
On New Books. Ralph C. Bean, Chairman.
On New Apparatus. George A. Cowen, Chairman.
Mr. N. Henry Black will show several interesting pieces of apparatus purchased in Germany.
A representative from the Weston Electrical Instrument Co. will show the latest school instruments.
Election of New Members.
Election of Officers.

11.00 A. M.
"Description of Laboratory Switchboard and Distribution of Commercial Current." A. M. Butler.

11.30 A. M.
Comparative test of the Thompson Reflectoscope and the Bausch and Lomb New Universal Balopticon.

12.00 M.
"The Westinghouse Air Brake." A. M. Butler, High School of Practical Arts.

12.30 P. M.
Lunch.

Afternoon Session

1–2.30 P. M.
Inspection of the laboratories and the building.

2.30 P. M.
Moving pictures of educational interest.

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MORNING SESSION.

The meeting was called to order by President Cowan, who called for the

Annual Report of the Secretary.

During the past year three regular meetings and a smoker have been held. On Saturday, March 29, we were entertained at Wentworth Institute where very interesting addresses were delivered by Professor Ira N. Hollis, then of Harvard, now President of Worcester Polytechnic Institute, and by Mr. Thomas A. Watson of Braintree.

On Saturday, May 24, Simmons College was our meeting place. Here a discussion led to the general belief that a course in Physics for girls should be different from one for boys. Mr. John Hamilton of West Roxbury spoke before the Association on Lord Kelvin.

Saturday, November 22, found us at Boston University, where the discussions were furnished by our own members.

At the smoker at the City Club on November 21 Mr. N. Henry Black gave an entertaining account of his year in Germany.

The membership is at present seventy-nine active and sixty-eight associate members, a slight increase over last year.

Respectfully submitted,

Alfred M. Butler, *Secretary.*

This was followed by the

Annual Report of the Treasurer.

Receipts.

Balance March 29, 1913	$203.54
Dues	279.00
School Science	82.50
Scientific American	47.40
Technical World	2.00
Popular Mechanics	10.00
Popular Electricity	5.00
National Geographic	2.00
Electrician and Mechanic	2.00
Reports sold	5.00
	$638.44

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Expenses.

Secretary's salary	$50.00
General expenses, secretary	43.56
School Science	82.50
Scientific American	47.50
Technical World	2.00
Popular Mechanics	10.00
Popular Electricity	4.30
National Geographic	2.00
Electrician and Mechanic	2.00
Printing	203.85
Expenses of meetings	8.25
	$455.86
Balance on hand	$182.58
	$638.44

Respectfully submitted,

PERCY S. BRAYTON, *Treasurer.*

Examined accounts of E. A. P. T. Asso. for year ending March 7, 1914, and found to be correct and as stated herewith.

CLARENCE BOYLSTON, *Auditor.*

Following is the report of the

COMMITTEE ON MAGAZINE LITERATURE,

Frederic H. Sawyer, *Chairman.*

Scientific American. November 15, 1913. "Photography by Invisible Light," by Prof. R. W. Wood, Johns Hopkins University.

November 22, 1913. "A Radical Improvement in Cabling," by Herbert T. Wade.

December 27, 1913. The World's Greatest Life-Saving Station."

January 3, 1914. "The Wright Automatic Stabilizer for Aeroplanes," by Carl Dienstbach.

January 17, 1914. "The Cleaning of Scientific Instruments Composed of Glass," by Albert B. Owens.

February 14, 1914. "Eliminating the Flicker from the Moving Picture," by Joseph B. Baker. "Where and How Radium is Obtained."

March 7, 1914. "Navigating Lights for the Panama Canal." "How the Locks of the Panama Canal are Operated."

The Electric Journal. December. "Artificial Resuscitation," by Charles A. Lauffler, M.D., Medical Director, Relief Department. Westinghouse Electric and Manufacturing Company. "Shop Testing of Electrical Apparatus." XII. "Alternating-Current Generators and Synchronous Motors." (Continued.)

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January, 1914. "The Engineering Evolution of Electrical Apparatus." I. "The Beginnings of the Alternating Current System," by Charles F. Scott. "Shop Testing of Electrical Apparatus". XIII. "Rotary Converters."

February, 1914. "The Engineering Evolution of Electrical Apparatus." II. "The Alternating-Current Generator in America," by B. G. Lamme. "Shop Testing of Electrical Apparatus." XIV. "Induction Motors."

Popular Electricity. December, 1913. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter IX.

January, 1914. "Elementary Electricity for Practical Workers," by W. T. Ryan. Chapter X.

February, 1914. "Elementary Electricity for Practical Workers," by W. J. Ryan. Chapter XI. "Measuring Instruments."

Cassiers not issued now.

World's Work. Each month an article on "Man and His Machines," giving brief descriptions of remarkable or useful devices; uniformly interesting, usually well illustrated; brief.

Popular Science Monthly. January, 1914. "Chabaneau: An Early Worker on Platinum." Interesting biographical article. (Nothing of interest in the other numbers.)

Century. (Nothing.)

Popular Mechanics. November, 1913. p. 623, "'Shooting-up' the Movies." p. 681, "Apparatus for Detecting Defects in Glass." p. 710, "A Self-supporting Manual Training School." p. 743, "Air Circulation in a Hot-air Furnace." (Very good.) p. 751, "Practical Telephony." p. 766, "Compensating Siphon: a Polarity Indicator." All are illustrated.

December, 1913. p. 803, "Prevention of Explosions in Mines." p. 845, "Every-day Uses of the Metric System." (Good.) p. 897, "Practical Telephony."

January, 1914. p. 56, "Electrically Propelled Ship." p. 127, "Simple Resistance Thermometer." p. 131, "Water-heating Attachment for Hot-air Furnace." p. 137, "Practical Telephony." p. 143, "A Fire and Burglar Alarm." p. 146, "Reversing Switch for Small Motor."

February, 1914. p. 201, "Plating with Molten Metal." p. 278, "Shop Notes." p. 281, "Practical Telephony." p. 285, "Torsion Galvanometer." p. 297, "D'Arsonval Galvanometer."

Electrical World, January, 1914. Vol. 63, No. 1, p. 39, "The Commonwealth Edison Testing Laboratories." Vol. 63, No. 2, p. 71, "World's Largest Transmission Line." Vol. 63, No. 2, "Radio Service on Lackawana R. R." Vol. 63, No. 2, p. 85; No. 1, p. 33, "The 150,000-Volt Big Creek Development." II. Vol. 63, No. 5, p. 260, "Alternating Current Electric Magnets." Vol. 63, No. 8, p. 421, "Resonance in Radio Telegraphy."

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Following is the report of the

COMMITTEE ON CURRENT EVENTS IN PHYSICS,

George W. Day, *Chairman.*

THE NITROGEN-FILLED TUNGSTEN LAMP.

A newly invented tungsten lamp, having a nitrogen-filled bulb, is now on the market. It not only gives a more powerful light than other types of tungsten lamps but it is said to have other advantages that make it more valuable for service especially for street lighting. The filaments are wound in helices, the blocking of the bulbs is avoided, and the efficiency averages about 0.5 watts per candle power. The following are three interesting forms: 1. Large units taking 20 to 30 amperes and run from A. C. circuits by means of small transformers giving a voltage depending upon the size of the unit. 2. Smaller units of low voltage, taking currents of 10 amperes or less, at voltages in some cases as low as 4 or 5 volts. The current consumption is from 0.6 watt to 1.25 watts per candle-power. These lamps are adapted for series street lighting on 6.6 ampere circuits, and for stereopticon lamps and automobile headlights. 3. Lamps to run on standard lighting circuits (110 volts). Large units of this type (several thousand candle-power) have an efficiency of about 0.5 watt per candle-power or better.

Besides high efficiency in these lamps, there are other features which may prove advantageous in certain cases: 1. The color is more nearly like daylight than that of the ordinary tungsten lamp. It is similar to the effect produced in running the ordinary tungsten lamp at a voltage about double its normal rating. 2. Its high intrinsic brilliancy, though less than that of the arc light, makes it especially suitable for the stereopticon work. 3. The candle-power (according to the watt consumption) continues practically constant during the whole life of the lamp, and the ultimate failure of these lamps is due to breakage of the filament.

(Condensed from article in *Boston Transcript*, Dec. 7, 1913.)

LONG AERIAL FLIGHTS.

In the issue of the *Scientific American* for Feb. 28, 1914, it is stated that Marc Bonnici who recently completed a flight from Paris to Cairo has announced his intention of flying from Cairo to the Cape of Good Hope. The trip may take two months and will be made under the auspices of the National Aero League.

The papers of this country have been discussing the project of transatlantic flight proposed by the Wanamaker-Curtis Company of Hammondsport, N. Y., which is said to have the backing of Mr. Rodman Wanamaker and Mr. Glenn H. Curtis, the indorsement of governors of the Aero Club of America and the at least implied indorse-

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ment of the Smithsonian Institution. Some fair objections to the feasibility of the project are set forth by the aviation editor of the *Boston Transcript* in the issue of Feb. 28, 1914. One of these is the inferiority of American motors for flying machines compared with those of France and Germany, and a second one is the difficulty of carrying the burden of the great weight of fuel and of lubricating oil needed for so long a continuous flight.

Photography by Invisible Light.

In the *Scientific American*, Nov. 15, Prof. Wood tells of his investigations of photography by waves of different lengths. He shows how the camera comes to supplement the spectroscope in the study of the heavenly bodies. A photograph of the moon by ultra-violet light shows a dark spot in the crater Aristarchus not shown by other means. By photographing minerals of known composition he was able to come to the conclusion that the dark spot indicates sulphur. This difference in the absorbing power of different substances in case of ultra-violet light is very great among animal and plant tissues. Although the ultra-violet light has not the penetrating power of the x-ray, probably it will be very useful in showing surface variations.

Falling Objects in a Mine Shaft.

The February number of *Machinery* reports some tests of falling bodies made by the Michigan College of Mines. Two smooth metal balls, two inches in diameter, were dropped from a point directly over a box of clay 4200 feet below. Neither of the balls reached the clay. One was found lodged on the east side of the shaft 800 feet from the surface. This east side was four feet from the vertical line in which the ball was started by burning the thread by which it was suspended.

Studying the Upper Atmosphere.

In a series of experiments to study the regions above Santa Catalina Island it was found that during the first eight miles the temperature dropped to — 85° C. Above that was found a belt of uniform temperature extending at least seven miles above the eight-mile point. A pair of balloons was hitched to the instruments. After the weaker balloon burst the other, then having all the load to support, started back and returned the instruments unharmed.

Sun Power.

Seven years of experimenting has produced at Cairo a sun power plant having an efficiency of 57%.

Nobel Prize.

The Nobel prize for 1913 goes to Kammerling Omnes. By liquifying and boiling helium he reached a temperature of — 271° C.

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A pocket wireless receiver of great sensitiveness is the invention of a Frenchman, Mon. Hurm. It consists of a special telephone receiver of 500 ohms resistance on which is mounted a detector of lead-platinum crystals. It is put in circuit with an improvised antenna and ground connection made.

Eiffel-tower signals are received in any part of France.

The *London Illustrated News* of Jan. 3, 1914, contains an account of experiments made in electrifying chickens at Poole, England.

Under electric stimulus growth is said to take place at twice the normal rate.

The island of Spitzbergen gives promise of becoming an important coal-producing center; 35,000 tons were shipped last year.

The aviation death toll for 1913 was 192.

German Aviator Does 1050 Miles Without Stopping.

Munich, Feb. 8.—Aviator Ingold today broke the world's record for an endurance flight. He remained in the air 16 hours and 20 minutes, and covered a distance estimated at 1050 miles without landing. Ingold started at Mulhausen, Alsace, and flew far to the north. He then proceeded southward to Munich, landing in a suburb.

Following is the report of the

Committee on New Books,
Ralph C. Bean, *Chairman.*

"Laboratory Exercises to Accompany Carhart and Chute's First Principles of Physics."

By Robert W. Fuller and Raymond B. Brownlee. Published by Allyn and Bacon.

The laboratory experiments which are to be performed by our pupils must vary according to what end we have in view. In this book are given 90 experiments for use of High School pupils. They are divided in the different parts as follows: Mechanics 31, Sound 5, Light 14, Heat 14, Magnetism and Electricity 26. The book itself covers 307 pages.

In the introduction are given some recommendations in regard to suggestive courses as well as handling the book. There are also given some directions to students which seem to be worth while.

Most of the experiments are known to us in one form or another though in many cases some new methods are given.

At the beginning of each experiment is number and title. The object is then stated in heavy type, followed by the apparatus used in that particular experiment. Instead of giving the directions for the experiment at once the authors have at this point given an introductory paragraph. This gives the pupil a better idea of what the

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problem is, and shows him the connection between the experiment and his ordinary experience. It enabes him to work out the directions of the experiment proper with reasonable intelligence. It also enables a class to be somewhat more free from the text-book.

A tabular form is given for the recording of data or observations, and also a form for calculated results. This is probably what we all do for our own class, but here it saves the teacher from writing it on the board. Under the two heads Discussion and Conclusion questions are asked which enable the pupil to crystallize his knowledge and formulate his ideas into some definite statements. They also serve as an excellent basis for review.

Among the ninety experiments it seems as if one could find the basis for a great variety of courses. No class would probably do the whole number in one year.

Another feature which the authors have aimed at though this is not new with them, is simplicity of apparatus. In many cases the work is accomplished with as good if not better results than with more elaborate apparatus.

RALPH C. BEAN.

Mr. Butler called the attention of those present to "The Constitution of Matter," a series of lectures delivered at Northwestern University, Evanston, Ill., in 1913, by Professor Joseph S. Ames of Johns Hopkins University. This book is published by Houghton Mifflin Company Boston. It consists of 237 pages divided into six chapters. It treats in simple terms of the modern aspects of matter, more particularly from the electrical point of view. It is a book that will prove of interest and value to those who desire to keep up to date.

FOR THE COMMITTEE ON NEW APPARATUS.

Mr. Cowen called upon Mr. Black who showed several pieces of apparatus brought from Germany.

HAHN'S TRACING COMPASS.

This consists of a brass encased magnetic needle about three-fourths of an inch in diameter, with a circular dise of one-inch diameter for a base. This base is divided by four notches into quarters. In use one notch should be placed at the part of the magnet from which the lines are to be traced, and the base turned so that the other notch is at the other end of the needle. A dot, made where this notch is, serves as the place where the rear notch is to be placed. By connecting the series of dots thus obtained, the lines of force from pole to pole are located. Cost of needle $ .65.

HAHN'S VOLTAMMETER.

This is the voltammeter, No. 960, put out by A. Kruss of Hamburg, at $17.50. It may be used as a double-scale voltmeter 0-1 volt or 0-10

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volts; and as a double-scale ammeter 0-1 ampere or 0-10 amperes. It is dead beat, and the pointer is very light weight, so that it responds very quickly. It has a thumb screw by means of which the pointer may be set on zero. Mr. Black showed the polarization of a voltaic cell with this meter, using a very large copper plate in 1-20 sulphuric acid, and a very small zinc wire. In this way the slow polarization over the large copper surface was very apparent by the dropping back of the needle toward zero.

Reaction Car and Wheel.

A. Kruss, No. 824, Cost $11. Consists of a bicycle wheel mounted horizontally with weighted rim and small track near the edge. A spring-driven locomotive when set on the track, causes the wheel to rotate backwards as the car moves forward. By proper regulation the car can be made to stand still while the wheel moves.

Lilliputian Arc Lamp.

Made by Kruss, listed in Knott's catalogue No. 70-125 at $38.50 duty free. Consists of a baby arc lamp mounted at a slant with convex lens so placed that a parallel beam is thrown horizontally. With this Mr. Black showed the spectrum produced through a direct vision spectroscope, and then showed the black line absorption spectrum with sodium flame. To get this a broad bat-wing bunsen flame was passed between the edges of two pieces of asbestos soaked in sodium chloride solution; the light from the arc lamp was passed edgewise through this flame.

Refraction of Light Apparatus.

Kruss No. 405 and 406. Cost $10.50. Consists of a rectangular glass tank, 12 x 12 x 2 inches, filled with water. In this is placed a metal sheet near the bottom of which is a polished cone with apex away from the observer. Parallel rays from a baby arc lamp (Kruss No. C 400, $22) come from behind the apparatus and, striking the cone, are reflected upwards and sideways. A movable ring with a slit in it makes it possible to allow only a small portion of this reflected light to be seen from the front. This narrow beam can be made to pass in any direction by moving the slit around. Thus the course of a ray of light from water into air can be easily shown, including internal reflection. By the use of another ring with several slits, a number of beams can be shown together, passing at different angles to the surface.

Electromagnet.

Kruss, No. 938. Cost $12. Consists of two coils end to end, with the free ends of the core conical-shaped, and close together. Mr. Black showed this as an excellent instrument to use for demonstrat-

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ing electromagnetic induction, by passing a single wire between the poles, when the coils are excited.

ALTERNATING CURRENT DEMONSTRATION APPARATUS.

Central Scientific Co., No. 2215. Cost $35. Kohl, No. 62,902. Cost 327. Mr. Black showed the action of the rotating field produced by use of a 4-volt direct current. The induction motor principle is readily shown by this piece of apparatus.

Mr. Hutchins then spoke of some pin-hole photographs taken by High School pupils, and showed some of the results of this work.

Mr. Cowen demonstrated a 110-volt transformer and rectifier, made by the L. E. Knott Apparatus Company. This machine will deliver rectified currents at 3, 6, 9, and 12 volts. These currents are useful for all kinds of lecture table demonstrations. The rectifier can be used all day without over-heating, so it is very useful for charging storage bells. When used as a transformer it delivers a 12-volt alternating current. The rectifier is of the electrolytic type. It weighs about 50 pounds, and is practically noiseless.

A glass dome hydraulic ram made by the same Apparatus Company was also shown. This is a huge ram, that can be placed on the high pressure laboratory water supply. While it is in operation every valve and moving part is in full view of the operator. It is as large and strong as the commercial ram.

Mr. C. P. Frey, representing the Weston Electrical Instrument Co. then gave a very interesting account of the object the Weston Co. has had in mind in the collaboration of the several monographs that have been publishd. He said in part:

The Weston Monographs were prepared with the definite object in view of attempting to co-operate with and assist science teachers in high schools and collegiate preparatory schools throughout this country.

Their context is exclusively on electrical subjects; and each deals with a particular theme.

For instance B-1 dwells upon the manifest advantages of training students engaged in laboratory work by means of standard apparatus, such as they will encounter in practical work after graduation. It also calls attention to the fact that it is inconsistent as well as unwise to attempt to perform modern progressive laboratory work by means of antiquated and obsolete apparatus. *It shows what should be done.*

B-2 contains a series of simple yet exceedingly instructive experiments, and presents suggestions that should be of great value in the preparation or amplification of an electrical course. *It tells what could be done.*

B-3 briefly describes several standard high grade and thoroughly reliable instruments; economical in price and particularly adaptable to high school work.

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In Monograph B-4, we have compiled interesting and important data which will indicate some of the experiments which *are actually being performed* in progressive High Schools in these United States. We accomplished this by reproducing the actual work of students without revision or alteration, together with sketches, data-sheets, reports and instructors' comments; as well as apparatus actually used.

We desire to explain as briefly as possible how B-4 has been produced.

Early in the Fall of 1913, we issued a letter to over 7000 science teachers on our list, in which we directed attention to the Monographs we had already issued, and requested suggestions relating to experiments in electrical measurements which they would like to see embodied in future Monographs. We were immediately deluged with replies, and as soon as it was feasible we began preparing data relating to the experiments most in demand.

We then conceived the idea of asking science teachers to furnish us with these experiments, instead of preparing them ourselves; and wrote to a number of those who were fortunate enough to possess a modern equipment, inviting them to contribute some specified exercises.

In this manner we hoped to fulfill the requests of science teachers by publishing the work of other science teachers.

The experiments offered are reproduced verbatim; but we have in some instances either simplified or elaborated connection diagrams. Otherwise the authority for the execution of the work is vested in the contributor cited. Necessarily there was much repetition, and it obviously became practicable to print only a few of the contributions we received, but we desire to gratefully acknowledge the assistance of those teachers whose work is not incorporated in this Monograph. Their tests were of great value to us, and in many cases it was exceedingly difficult to make a choice.

Entirely aside from their intrinsic pedagogical value, the majority of these experiments have a significance which cannot fail to arrest the attention of the progressive instructor. They prove conclusively that the trend of physics teaching is toward the practical application of fundamental principles.

They indicate also that laboratory work requiring the use of instruments of precision may be successfully performed by young students of either sex.

In conclusion we desire to direct special attention to the Nodon Valve and Rectifier experiments; because they are not only of the greatest interest pedagogically, but since they also possess utilitarian properties, in that they indicate how a teacher who has only alternating current service available, may easily and cheaply transform to direct current; and thereby open up a greater realm of electrical experiments specially suited to the High School Laboratory.

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In the course of his remarks Mr. Frey desired especially to call attention to the question as to whether or not the word Weston,

* Contributed.

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when referred to by authors in text-books, means an advertisement or merely relates to a distinct type or class of instrument, an invention best known by the name of its inventor. In such an event, is the term used just as is a Wheatstone bridge, a Damill cell, etc.

NOTE. It is the intention of the Weston Co. to supply all the members of the association with the monographs, as well as the charts recently sent out. If any member has not received such monographs a card to the secretary of the Association, Mr. Butler, will be appreciated.

On recommendation of the Executive Committee, the following were unanimously elected to active membership:

A. B. Newhall, Wentworth Institute, Boston, Mass.
L. R. Perkins, Dean Academy, Franklin, Mass.
W. R. Trowbridge, Technical High School, Providence, R. I.

The following officers for the year 1914 were then elected:

President, W. H. Timbie, Wentworth Institute.
Vice-President, H. W. Le Sourd, Milton Academy.
Secretary, A. M. Butler, Boston, Mass.
Treasurer, P. S. Brayton, Medford, Mass
Executive Committee, Fred H. Cowan, Fred R. Miller, Clarence Boylston.

Mr. Butler then spoke briefly on

DESCRIPTION OF PLUG TRANSFER BOARD AND DISTRIBUTION OF CURRENT IN THE HIGH SCHOOL OF PRACTICAL ARTS.

In each of the laboratories and the lecture room there is a plug transfer board, supplied with 110-volt alternating, 110-volt direct, and 12-volt storage battery current. The alternating current supply is from the regular commercial source. The direct current supply is from a motor generator set in the basement. This consists of a 15 horsepower 220-volt induction motor which runs a direct connected 8.5 kilowatt dynamo. The storage battery of 10 Edison nickel iron cells, is in the physics laboratory, and is kept up to constant voltage, by means of a small motor generator set in the basement. This set is running pretty continuously, supplying also a current to charge the storage batteries of the chloride accumulator type, used for bell and telephone circuits. The battery "floats" on the circuit.

The motor generator set may be started in six places, the three laboratories, the lecture room, the moving picture booth in the assembly hall, and at the switchboard in the basement. This starting is accomplished by means of a remote control starting mechanism located at the motor. It is operated by the regular alternating current. The voltage is controlled between 110 and 10 volts by

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means of any one of three field rheostats, located respectively in the Physics laboratory, lecture room, and basement switchboard.

The plug transfer boards are divided into two panels, one for the switches and meters, the other with sets of receptacles and sockets into which fit wire cords with corresponding sockets and receptacles on either end. On this transfer part of the board there are four separate parts, three connected with the three sources of supply. The fourth set is connected to the various outlets located in various parts of the laboratory, such as lecture table, students tables, wall benches, apparatus room. These four parts are in a checker-board arrangement of thirteen horizontal and as many vertical rows as there are outlets to be supplied. The two upper rows represent the outlets, and are made up of plugs. The other eleven rows are receptacles, two rows for alternating, two for direct 110 volt, and seven for storage battery supply.

All the receptacles in one horizontal row of the supply part are connected to one bus bar, positive and negative respectively, for the high voltage supply, and for the storage battery part, the upper six are attached to the terminals of five of the ten series joined cells, while the last is connected to the other end of the remaining five cells. Thus by placing the receptacles in first and second horizontal row, attachment is made to one cell; first and third row gives two cells; first and sixth gives five cells; sixth and seventh gives five cells; first and seventh gives ten cells. In this manner any number of cells in series may be connected to any outlet by inserting the other ends of the two cords over the plugs of the desired outlet on the upper two rows. In like manner attachments may be made between 110-volt D. C. and 110-volt A. C. and any outlet in the laboratory.

On the other panel of the board are voltmeters and ammeters for direct and alternating current. These can be placed in circuit by means of the above-mentioned cords. They are of the illuminated-scale type, the lamps of which can be turned on at will by a switch on the board. Below the remote control switch is a red pilot lamp which shows when the dynamo is up to its full voltage.

On this panel there is also a switch which starts an air compressor by remote control. This compressor supplies air on the lecture tables at fifteen-pounds pressure. There is also a receptacle for plugging in a lantern signal, run by means of the storage battery. At the lantern stand located in each laboratory and in the lecture room there is a corresponding receptacle to which the signal lamp or buzzer is attached.

In the moving picture booth the motor is started by means of a snap switch. Here there is a pilot lamp, voltmeter, fan, switches for controlling the moving picture machine and dissolving view stereopticon. There is also a remote control switch by which the hall lights may be turned on or off.

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The alternating current supply is fused for thirty amperes; the direct current dynamo supply for forty amperes. The storage battery is fused for fifteen amperes.

Owing to complications which arose at the last minute, the comparative test of the two lanterns as announced on the program, had to be abandoned, and Mr. Butler showed the various features of the Bausch and Lomb New Universal Balopticon, as furnished and installed in the lecture room of the Practical Arts High School. This included opaque, lantern slide, microscopic, and vertical projection. Such an outfit with mechanical stage and swinging arm for the microscope may be purchased for the price of the old type of convertible balopticon, $225 net. Thus equipped it makes a thoroughly up-to-date scientific lantern.

A lunch, prepared by members of the school in the school kitchens, was then served in the lunch room.

An inspection of the building followed the lunch.

AFTERNOON SESSION.

WESTINGHOUSE AIR BRAKE.

A M. Butler, High School of Practical Arts.

Through the kindly interest and generosity of the Westinghouse Air Brake Company, of Pittsburgh, the Association has been fortunate in securing free of charge the seven charts that are being sent out with this report, in a separate mailing tube. It was through the New England representative of the company, Mr. Nellis, that this was made possible, and the speaker wishes to express his appreciation of this kindness before discussing the air brake itself.

Most of us remember the days of the hand brake on passenger and freight trains. Many a night in our boyhood days we have been awakened by the shrieking of the locomotives calling for "down brakes." Those days are now of the past, happily, through the inventive genius of George Westinghouse, himself a brakeman at one time.

The air brake in its present form affords a means whereby, on the one hand, control of the brakes is in the hands of the engineer at all times that the train is in motion, and on the other hand, should the train be broken in two at any time, the whole train automatically comes to a stop. In some of our Physics text-books we read that it is by means of the triple valve that this is done. It is the action of this triple valve that is the main object of this discussion. This valve serves as a means of directing the course of the compressed

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air that is supplied to each car from the air pump on the locomotive. It has three openings to it, from which it derives its name. These openings or ports are connected to the brake pipe, auxiliary reservoir and brake cylinder, respectively.

Let us now turn to the charts and follow through the changes that take place in the valve when the engineer by means of his brake valve, changes the pressure of the air in the brake pipe.

NOTE:—This description is taken from Instruction Book No. 5038, Westinghouse Quick Action Automatic Brake Equipment.

In charging the system, compressed air flows from the main reservoirs to the brake valve, entering it through passage A, Fig. 37, and flowing to chamber A above the rotary valve (represented by space A at center of rotary valve, Fig. 37). Port *j*, through the rotary valve registers with port *f* in the seat, allowing air to flow to the feed valve, which is attached directly to the brake valve as shown. The feed valve reduces the pressure of the air from that carried in the main reservoir to that which is to be carried in the brake pipe. From the feed valve the air re-enters the brake valve through port *i*, which has two branches.

One branch leads to port *l* in the seat (*direct application and supply port*) through which air flows to the cavity *c* in the rotary valve, thence to the equalizing port *g* in the seat, and through this to the chamber D above the equalizing piston in the lower part of the brake valve. Chamber D is connected through port *s* and pipe connections as shown to the equalizing reservoir. The purpose of the equalizing piston and reservoir will be described later. A branch from the equalizing reservoir pipe leads to the black hand of the duplex air gage which therefore really registers the pressure in chamber D and the equalizing reservoir. However, as will be seen from what follows, this bears such a relation to the brake pipe pressure that the black hand of the gage is usually considered to show brake pipe as well as equalizing reservoir pressure.

The other branch or port *i* leads from the feed valve to the brake pipe connection at Y and to the underside of the equalizing piston. Therefore, with the brake valve handle in *Running* position, the feed valve maintains a practically constant pressure (70 lbs. being the usual pressure for which the feed valve is adjusted) in the brake pipe and on the under side of the equalizing piston and the same pressure in the equalizing reservoir and chamber D on the upper side of the piston.

The end of the equalizing piston stem is called the "equalizing discharge valve," which, when open, allows air from the brake pipe to flow through port *m*, past the equalizing discharge valve and through port *n* to the service exhaust fitting and atmosphere at EX. This valve is held to its seat during the time the brake pipe is being charged as above, as well as at all times when the air pressure (in

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pounds per square inch) is the same on the under and upper sides of the piston, because the pressure of the air above the piston acts on the entire area of the piston, while that below it acts on an area which is less than that above by the amount of the cross-sectioned area of the piston stem. This makes the total pressure on the top of the piston slightly higher than that below, thus holding the piston down and the equalizing discharge valve on its seat.

Air entering the brake pipe at Y flows through this pipe the entire length of the train, and through the branch pipe to the triple valve on each vehicle. Passing through the branch pipe and branch pipe cut-out cock on the engine, air enters the plain triple valve through port *e* to chamber *f* and through passages *g* to chamber *h*, in which the triple valve piston 5 moves. The air pressure in chamber *h*, acting on the face of the piston, forces it to its extreme position to the right, which is *Release and Charging position.* In this position air can flow from chamber *h* around the piston through feed groove *i* in the bushing and *k* in the piston seat into chamber *m* and thence, through the pipe connection at R, as shown, to the auxiliary reservoir. During the time the brake valve handle remains in *Running* position, air continues to flow from the feed valve through the brake valve, brake pipe, and triple valve to the auxiliary reservoir in this way until the system is charged up to the pressure at which the feed valve is adjusted to close, after which any leakage from the system, which reduces the pressure slightly, will cause the feed valve to open again and supply air to the system. As a very slight drop in brake pressure will cause the feed valve to open, it will be seen that the brake pipe and auxiliary reservoirs are maintained at a practically constant pressure as long as the brake valve handle remains in running position and the feed valve is operating properly.

From Fig. 37 it will be seen that the triple valve piston 5 has a stem on which are two collars. Between these two collars is a slide valve 6, shorter than the distance between the collars on the piston stem, so that there is a certain amount of clearance or "lost motion" between the piston stem and the slide valve. The function of this slide valve 6 is to make proper connections between the space *m* (auxiliary reservoir pressure) and the brake cylinder port *r* in the seat of the valve, or between the brake cylinder port *r* and the exhaust port *p*, also in the seat, or to close these ports, according to the positions to which the slide valve is moved by the triple valve piston, as described later. In the *Release* position shown, Fig. 40, air at auxiliary reservoir pressure is acting above and on all sides of the slide valve, but cannot flow past or through it, since all ports through the valve are closed. The exhaust cavity *n* in the face of the valve, however, makes an opening across from the brake cylinder port *r* in the seat to the exhaust port *p*, so that the brake cylinder is then connected through the pipe connection to the triple valve and

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the ports named to the exhaust opening and atmosphere. Any compressed air contained therein will then flow to the atmosphere, thus permitting the release spring acting on the opposite side of the piston to force it back to release position and release the brake shoes from the wheels.

The air from the brake pipe flowing through the branch pipe and cut-out cock on the tender and cars enters the quick-action triple valve, through chamber *a* in the lower case and port *c*. The passage of air through this triple valve to the auxiliary reservoir is then the same as described above for the plain triple valve, the ports, cavities, etc., being lettered the same. The parts in the lower portion of the quick-action triple valve are practically additions to the upper portion (which is, in effect, a plain triple valve), their function being to vent brake pipe air directly into the brake cylinder, thus producing a quick-action or "emergency" application, as described later. As they do not act, however, except when an emergency application takes place, they need not be referred to further here.

The condition just described, viz., the brake valve handle in *Running* position, the triple valve pistons and slide valve in *Release* position, and the brakes released, and the auxiliary reservoirs charged and maintained at the pressure for which the feed valve is adjusted ("standard brake pipe pressure"), is the normal condition of the brake system when the train is running over the road and the brakes are not being used.

Service Application.

To apply the brakes in service the brake valve handle is moved to a position which allows air to escape from the brake pipe to the atmosphere. This reduces the pressure on the brake pipe side of each triple valve piston in the train below that in the auxiliary reservoir, acting on the opposite side of the piston, which differential causes the triple valve piston and slide valve to move to *Service* position. This opens the service port through the triple valve, which permits air to flow from the auxiliary reservoir to the brake cylinder and apply the brake, as has been explained.

The system being charged as has been described, say to 70 lbs. brake pipe pressure, when it is desired to make on ordinary "service" stop, the brakes are applied by placing the brake valve handle in *service application* position, Fig. 38. This cuts off all air supply to the brake pipe or equalizing reservoir and opens the small port *e*, called the *preliminary exhaust port*, leading to chamber D and the equalizing reservoir. This permits air to escape from above the equalizing piston through port *e* in the rotary valve seat, cavity *p* in the rotary valve and the *direct application and exhaust port*, *k*, to the atmosphere. This at once reduces the pressure of the air on the top of the equalizing piston below that in the brake pipe under the piston, and the higher pressure forces the piston upward, raising

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the attached equalizing discharge valve from its seat and allowing air from the brake pipe to flow through opening *m*, past the valve, and through passage *n* and the service exhaust fitting to the atmosphere. For illustration, suppose that only a moderate application of the brakes is desired, requiring, say a 10-lb. reduction in brake pipe pressure. The brake valve handle is left in *service application* position until the black hand of the duplex air gage shows that a 10-lb. reduction has been made, by dropping from 70 to 60 lbs., and is then returned to Lap position. This closes the preliminary exhaust port *e*, preventing further reduction, and the other ports through the rotary valve and seat also remain closed, Fig. 39. It will be noted that the gage connection leads out from the equalizing reservoir pipe, so that a 10-lb. reduction observed was that made in the equalizing reservoir and chamber D, above the equalizing reservoir, the pressure in which now stands at 60 lbs. It will now be clear that the *purpose of the equalizing reservoir* is to add volume to the chamber D above the equalizing piston. Without the equalizing reservoir this volume is so small that, with the brake valve handle in *Service* position, its pressure would drop to zero almost instantly and it would consequently be very difficult to make a moderate brake pipe reduction and practically impossible to obtain the exact amount of reduction desired in any given case. But with the volume of chamber D increased by that of the equalizing reservoir, sufficient capacity is obtained so that with the brake valve handle in Service position it takes from 6 to 7 seconds for the pressure above the equalizing piston to drop from 70 lbs to 50 lbs., which is slow enough to permit the reduction to be stopped at any desired point, as indicated by the air gage.

While the pressure in chamber D is being reduced from 70 lbs. to 60 lbs. and the brake valve handle placed in *Lap* position, holding the pressure of 60 lbs. constant above the equalizing piston as explained, the brake pipe pressure is falling also, due to air escaping through the service exhaust fitting to the atmosphere, as also described. Whether this flow of air from the brake pipe ceases at once or continues for a period of time after the handle is placed in *Lap* position depends upon whether the train is a long or short one. With a short train the total volume of air in the brake pipe is not very great, so that it can escape through the service exhaust nearly as fast as the air in chamber D and the equalizing reservoir is flowing out through the preliminary exhaust port *e;* thus the pressure below the equalizing piston is falling at about the same rate as that above.

In such a case, as soon as the pressure in chamber D ceases to fall, the brake pipe pressure below the equalizing piston becomes slightly less than that above the piston and the higher pressure forces the piston downward, seating the equalizing valve and preventing further flow of air from the brake pipe.

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On a long train, however, the total volume of air in the brake pipe is large, so that it takes very much longer for sufficient air to escape through the service exhaust fitting to reduce its pressure from 70 lbs. to 60 lbs. and the pressure below the equalizing piston therefore falls at a much slower rate than that above it. In such a case, air continues to escape from the brake pipe after the handle has been placed in *Lap* position for a period of time, depending upon the length of the train, until the brake pipe pressure has been reduced slightly below that in chamber D, when the equalizing piston is forced downward and the service exhaust opening closed as explained. It will be seen that the equalizing piston and valve automatically measure the amount of air which must be discharged from the brake pipe in order to obtain the desired reduction and govern the rate of its discharge, according to the length of the train, to a degree which would be impossible were the flow of air from the brake pipe to the atmosphere directly controlled by the brake valve handle, as in the case of the old three-way cock, and, by closing slowly as the pressure falls, prevents a surge of air to the head end of the brake pipe which, if the opening were closed quickly, might cause some of the head brakes to release.

The description which follows will apply equally to the operation of the plain and quick-action triple valves, except where special reference is made to one or the other of these valves. As the brake pipe is connected to chamber *h* of each triple valve, a reduction in brake pipe pressure, as described, will lower the pressure on the brake pipe side of the triple valve piston below that of the auxiliary reservoir on the opposite side of the piston. The higher auxiliary reservoir pressure will then cause the piston to move in the direction of the weaker pressure, thereby closing communication between chamber *h* and the auxiliary reservoir through feed groove *i*. Attached to the piston stem is a pin valve 7, called the *graduating valve*, which, when seated, Fig. 40, closes communication between port *w* leading from chamber *m* to the graduating valve seat in the slide valve and the service port *z* leading from the graduating valve seat to the face of the slide valve. The first movement of the triple valve piston also unseats the graduating valve 7 so that the air in chamber *m*, entering port *w*, flows to the service port *z*.

There is a small amount of clearance between the slide valve 6 and the collar or "spider" on the end of the triple valve piston stem so that the first movement of the piston, which closes the feed groove *i* and opens the graduating valve 7, does not move the slide valve, but brings the spider on the stem against the end of the valve. Further movement of the piston then causes the slide valve to move until it has closed communication between brake cylinder port *r* and exhaust port *p* and opened port *r* to the auxiliary reservoir through port *z* and *w*, as shown in Fig. 38. The piston then comes into contact with the graduating stem and the resistance of the

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graduating spring combined with the reduction in auxiliary reservoir pressure then taking place prevents further movement of the parts. The valve is then in *Service* position and air from the auxiliary reservoir flows through the service port to the brake cylinder, forcing its piston outward and applying the brake. While the pressure in the brake cylinder rises, that in the auxiliary reservoir falls and (the brake pipe reduction being 10 lbs.) tends to become lower than that in the brake pipe. As soon, however, as the pressure on the auxiliary reservoir side of the triple valve piston falls slightly below that on the brake pipe side the higher pressure causes the piston to move back toward its former (*release*) position, until the graduating valve is seated, closing communication between ports *w* and *z*. This prevents further flow of air from the auxiliary reservoir, the pressure in which is then practically equal to that in the brake pipe, and at the same time prevents further movement of the triple valve piston toward *Release* position, because the slightly higher pressure on the brake pipe side of the piston, which was able to move the piston and graduating valve alone, is not sufficient to move the slide valve also. The parts are then in *Service Lap* position, Fig. 39, and, assuming that there is no leakage, the brake pipe and auxiliary reservoir pressure will remain balanced and the brake cylinder pressure held constant until the brake pipe pressure is further reduced, in order to apply the brakes harder; or increased, in order to release the brakes.

If a further reduction in brake pipe pressure is made, after the parts are in *Service Lap* position, the reduction of pressure on the brake pipe side of the triple valve piston below that on the auxiliary reservoir side causes the piston and its attached graduating valve to move as described for the first service application of the brakes. The slide valve, however, is already in *service* position, consequently as soon as the graduating valve is opened air from the auxiliary reservoir flows to the brake cylinder and increases the pressure therein, thus increasing the pressure of the brake shoes against the wheels. If the brake pipe reduction is continued indefinitely, the auxiliary reservoir pressure will continue to fall and the brake cylinder pressure rises until they become equal, or "equalize." This occurs at about 50 lbs. cylinder pressure, when carrying 70 lbs. brake pipe pressure.

After the pressures in the auxiliary reservoir and brake cylinder have "equalized" in this manner, air ceases to flow out of the reservoir and into the cylinder, because there is no longer any difference of pressure to cause a flow. Consequently, when the brake pipe pressure is reduced below the "point of equalization," the brake cylinder pressure cannot rise above the "equalizing point," even though the brake pipe may be reduced far below 50 lbs. For this reason, therefore, nothing is gained by reducing the brake pipe pressure below the "equalizing point," as explained above. Moreover, it

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is a needless waste of air and interferes with the proper release of the brakes.

Holding Brakes Applied.

After the brakes have been sufficiently applied the brake valve handle is returned from *Service Application to Lap* position, Fig. 39, and, as has already been described, in this position the brake valve prevents air from flowing into or out of the brake pipe, thus holding the brakes applied until a further reduction or a release is made.

Release and Recharge.

To release the brakes and recharge the auxiliary reservoirs, air is admitted through the brake valve to the brake pipe. This increases the pressure on the brake pipe side of each triple valve piston above that on the other side, causing the piston and slide valve to move back to *Release* position, which permits the air in the brake cylinder to flow to the atmosphere through the triple valve exhaust port, thus releasing the brakes and from the brake pipe through the feed groove around the triple valve piston to the auxiliary reservoir, which is thus recharged.

When the brakes are released by moving the brake valve handle from *Lap* to *Release* position and then to *Running* position, *in Release* position, Fig. 40, air from the main reservoir flows through port *a* in the rotary valve to cavity *b* in its seat, then through cavity *c* in the rotary valve to port *c* and thence directly into the brake pipe. At the same time air in cavity *c* also flows through the equalizing port *g* to chamber D above the equalizing piston and to the equalizing reservoir. Air from the main reservoir also flows through port *j* in the rotary valve into the preliminary exhause port *e* and to chamber D. While in this position, air from the main reservoir also flows through the warning port *r* in the rotary valve to the direct application and exhaust port k and the atmosphere, with considerable noise. This indicates to the engineer that the handle is in *Release* position and attracts his attention if the handle is left there by mistake.

After the handle has been in *Release* position the proper length of time it is moved to *Running* position, which closes the warning port, stops the direct flow of air from the main reservoir to the brake pipe, chamber D and the equalizing reservoir, and opens the supply of air to these parts through the *feed valve*, in which position the brake pipe, chamber D and the equalizing reservoir are charged up and maintained at the standard pressure to be carried by the feed valve, as fully explained above. When the pressure in the brake pipe is increased, it raises the pressure in chamber *h* on the face of the triple valve piston, Fig. 39 (which is in *Service Lap* position) above that in the auxiliary reservoir on the opposite side of the piston, causing it to move back, carrying the graduating valve and slide valve with it, to *Release* position as

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shown in Fig. 40. This movement opens the brake cylinder to the atmosphere through port *r*, cavity *n* in the slide valve and exhaust port *p*, thus releasing the brake, and opens feed groove *i* around the piston so that the auxiliary reservoir is recharged, as explained before.

EMERGENCY APPLICATION.

When it is desired to make the shortest possible stop the brake valve handle is placed in *Emergency* position, Fig. 41. This opens the brake pipe directly to the atmosphere through the large port *l*, cavity *c* and port *k*, causing a sudden and rapid drop in brake pipe pressure. In *Emergency* position also, cavity *p* in the rotary valve connects the feed port *f* and the preliminary exhaust port *e* to the exhaust port *k*, thus allowing the air in the feed port, chamber D and the equalizing reservoir to escape to the atmosphere. The reduction in brake pipe pressure thus caused takes place so much more rapidly than during a service application of the brakes that the pressure in chamber h, on the brake pipe side of the triple valve piston, is reduced at a much more rapid rate than can that in the auxiliary reservoir on the opposite side of the piston. The difference of pressure thus obtained is sufficient to cause the piston to move over to *Emergency* position, Fig. 41, compressing the graduating spring.

Up to this point, all settlements made regarding the operation of the triple valve have applied equally to the plain or quick-action triple valve, but during an *Emergency* application their action is different.

When the piston and slide valve of the *plain triple valve* move to *Emergency* position, Fig. 41, the brake cylinder port *r* is uncovered, and air from the auxiliary reservoir flows past the end of the slide valve directly through port *r* into the brake cylinder until the brake cylinder and auxiliary reservoir pressures become "equalized." The pressure obtained in the brake cylinder is no higher than when a full service application is made, but the maximum pressure is obtained more quickly.

When the piston and slide valve of the *quick-action triple valve* move to *Emergency* position, Fig. 41, port *s* in the slide valve registers with port *r* in the seat, allowing air to flow from the auxiliary reservoir to the brake cylinder. Port *s* is small, however, and in this position the slide valve also opens port *t* in its seat, allowing air to flow from chamber *m* through port *t* to the chamber above the emergency piston 8. The other side of the emergency piston 8 is connected to the brake cylinder, in which there is no air pressure, consequently the emergency piston is forced downward, pushing the emergency valve 10 from its seat and allowing the air in chamber Y above the check valve 15 to flow past the emergency valve 10 to chamber X and the brake cylinder. Previous to the downward movement of valve 10 the air in chamber Y was at a pressure slightly

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less than the auxiliary reservoir. How much less it is depends on the tension of the spring 12 in valve 15. Brake pipe air in *a*, below the check valve 15, then raises the check valve against the resistance of its spring 12 and also flows to the brake cylinder through the passages mentioned. During an emergency application, therefore, the quick-action triple valve supplies air to the brake cylinder from the brake pipe as well as from the auxiliary reservoir. Port *s* is small, so as to restrict the flow of air from the auxiliary reservoir to the brake cylinder and thus allow as much air as possible to enter the brake cylinder from the brake pipe. Approximately 60 lbs. brake cylinder pressure is, therefore, obtained on emergency applications, the air from the brake pipe increasing the cylinder pressure about 20% above the maximum obtainable with a full service application.

Not only does the air vented from the brake pipe give a higher cylinder pressure, but it causes a local drop in brake pipe pressure *at the triple valve*. This sudden drop in pressure causes the next triple valve to apply in "quick-action," and it is the next, thus transmitting the quick action from triple valve to triple valve, serially, throughout the train in a very short time, with the result that all the brakes in the train are applied in a small fraction of the time which would be required if all the valves were plain triple valves and all the brake pipe reduction had to be made at the brake valve.

The release after an emergency application is made the same as after a service application, except that it requires a longer time, the brake pipe having to be recharged from zero to slightly above the pressure in the auxiliary reservoirs before the triple valve pistons can move to release position. Emergency piston 8 is not tight fitting, so that when the port *t* is covered as the slide valve moves to the right, piston 8 is slowly forced upwards, the air above it escaping into X and out through the exhaust pipe with the rest of the brake cylinder air. Valve 10 thus reseats itself and Y becomes filled with air directly from the brake pipe. When the pressure of this air in Y, added to the downward pressure of spring 12 equals the brake pipe pressure valve 15 reseats itself, and the air in Y is ready for another emergency application.

A description of the Powers 6 A Cameragraph followed this.

This was followed by a demonstration in the lecture room of the Edison Home Kinetoscope, in the form of a twenty-minute reel, on Logging in Maine

The members present then spent an hour in the assembly hall of the school where four reels were shown with the Cameragraph.

It was through the interest of Mr. Zeller of the F. H. Thomas Co. that the Association was able to get these reels free of charge. Mr. George Corbet, friend of Mr. Zeller, of the General Film Co. was the person whose generosity made this possible.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SIXTY-EIGHTH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, May 9, 1914

at Springfield, Mass.

FORENOON MEETING.

At the Springfield Technical High School.

Address of Welcome. Principal C. F. Warner.

The Magnetic Circuit. A Practical Method for Making Magnetic Computations. Professor V. Karapetoff, Cornell University.

BUSINESS MEETING.

Election of New Members.

Reports of Committees.

Inspection of Laboratories.

LUNCH.

AFTERNOON MEETING.

At the Central High School, Springfield.

Piano Recital (with explanations). Professor Karapetoff.

The Bosch Magneto. Mr. L. C. Carlton.

The Maxim Silencer.

The Telegraphone. Mr. H. L. Washburn.

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MORNING SESSION.

The meeting was called to order by President Timbie, who introduced Principal Warner, one of the charter members of the Association, and at present an honorary member.

Mr. Warner spoke as follows:—

ADDRESS OF WELCOME.

My duty is a very pleasant one. Since I have the good fortune to be counted among the eighteen ancient and honorable charter members who met at the Hotel Thorndike in Boston in February nineteen years ago for the purpose of founding this Association, I may be permitted to refer to the personal gratification I feel in welcoming the present members and their friends on this, the second meeting of this Association in Springfield. At your first meeting here fifteen years ago, you were instrumental in bringing to Springfield from the Tripler Laboratories in New York the first supply of liquid air ever exhibited in New England. The intense popular interest in seeing the air we breathe reduced to a liquid form made this a record meeting in the history of the Association. It was in a Springfield laboratory, too, that, shortly after your first meeting here, solid particles of oxygen were for the first time, so far as I know, produced by the rapid evaporation of a body of liquified air under the receiver of an air pump. Having been a personal witness to these achievements, effected largely through the instrumentality of this Association, I feel it a privilege to be permitted to extend the welcoming hand on this occasion and to express the hope that your second meeting may be as memorable as the first.

It is perhaps not stretching the imagination too much to say that the Eastern Association of Physics Teachers has played the part of an electron in the educational world. I mean that it has distinguished itself by being a very small body with a large capacity for doing things. If I am not mistaken it was the first body of teachers to break through the tradition of holding large and more or less ineffective general teachers' conventions. A few teachers of physics came together in Boston nineteen years ago, as I have said, and decided to organize a small working corporation for the promotion of better methods in teaching their specialty. It proved to be a very promising departure from the first, so that it was not long before a similar movement was entered upon by the teachers of chemistry, the teachers of English, of history, of mathematics, of modern languages, art, manual training, and other subjects. The physics teach-

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ers thus led the way to a change of method in doing educational convention work which has proved to have a marked advantage over the older methods of the general teachers' conventions.

It is not at all surprising that this method has proved successful because it is so eminently practical. It might be described as a live-wire method of doing things. The cardinal features of your plan, as stated in your manual, have been: first, short papers based on practical experience; second, entire freedom of debate; third, brief visits to the best modern laboratories; fourth, occasional addresses by advanced teachers and investigators in the department of physics on topics marking the progressive tendencies of the science as a source of inspiration.

This is your sixty-eighth meeting. You have produced over two hundred papers and reports on scientific matters. Of these you have published seven or more pamphlets dealing with your specialty for free distribution. You have listened to over sixty scientists who are leaders in education or in scientific research, among whom I find such names as Dr. Charles W. Eliot, the dean of American college men; Prof. A. E. Dolbear, inventor and teacher; Prof. C. R. Cross, the physicist; Dr. G. Stanley Hall, the psychologist; Dr. Hugo Munsterberg, the German critic of everything American; Prof. E. C. Pickering, the observatory director; Prof. David Todd, the astronomer. This is a record that any body of teachers should be proud of.

It would be out of place for me at this time to advocate any change in your program of work or even to suggest subjects for discussion, but there is one topic that I cannot refrain from saying just a word about because I have felt for some years that the great attention paid to the practical and up-to-date, which has been forced upon us in recent years, has caused us to overlook some of the advantages in the older, I might say historical, methods of teaching science. A distinguished college president has said that "in a broad way there is but one subject of study and that is the study of history. Every science has its biographical or historical side. Some individual brought out its principles, made its discoveries, gathered its truths into systematic and presentable form; but that work was a part of the striving, upward pushing of the human spirit of which history is the record. History, briefly conceived, gathers together all the achievements of humanity in science, in literature, and in philosophy, brings out the salient and significant, points to facts and discoveries which had successors in the world of thought and action, and presents the record as the story of humanity's life." I offer this not as a plea for the study of history as such, but for an inclusion of more of the history of science in our science teaching; and of course the suggestion would also apply to the history of mathematics, of literature, and of every department of educational work. It would seem exceedingly important that students should be led to acquire some insight into the long process which has led

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from ignorance to knowledge, from a superstitious subservience to the powers of nature, to their mastery and control. The deeds of the great men of science constitute a marvelous record, which it seems to me, should in some measure be laid before the students' vision. They should know how the heroes of science have toiled and suffered for the discovery of truth, with what crude and simple aids they have been able to make their discoveries of the fundamentals, and how the truth once found has uplifted and enlarged human spirit and increased the obligations of humanity in every succeeding generation. The young people of our day have much to learn, if they understand the fundamental principles and the modern applications of physical science. But is there not a danger that in our anxiety to secure this knowledge to them we may allow them to lose some of the rich human interests and inspirations of science by failing too often to recognize the value of the historical point of view?

But I must not forget that it is my function merely to assure you that you are welcome to the use of our halls and laboratories and to whatever facilities you may find for carrying out your program. Those of you who were here fifteen years ago will observe that Springfield has experienced a rapid and vigorous growth in the meantime. You will be most interested in the evidence of this growth to be found in the new buildings and enlarged equipments provided for the public service. The high school population has increased almost four-fold. Instead of one large high school building we have two, and a third (a million dollar building) in the process of construction. We have a new public library and three new branch library buildings. We have built several new elementary schools, one of them the largest and perhaps the best appointed in the state. Our new Municipal Building we are assured ranks high among the ten or twelve products of American architecture remarkable for beauty and for completeness of design and construction. Of our older institutions, you will not forget those two gems of our educational plant, the Art and the Science Museums near the Public Library. If I may speak especially of this school I think you will find here some interesting developments in the adaptation of science to the needs of a somewhat unique departure in school work. Our shops are laboratories of applied science, and some of our collections used in industrial history will be of interest to teachers of science, as will also some of our facilities for teaching mathematics. In a broad sense an association like this will find every department of work an institution that has had its origin in the demands of a scientific age, of vital interest. I bespeak for you a cordial welcome in every corner of this building.

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Professor Karapetoff then spoke on,—

THE MAGNETIC CIRCUIT.

NOTE.—It was expected that Professor Karapetoff would have his lecture in writing. As he did not, and felt indisposed to write it up afterwards, the Secretary reports his remarks very briefly, and refers the reader to the first chapter of Professor Karapetoff's book, "The Magnetic Circuit," published by the McGraw-Hill Book Company, of New York. In this chapter on "The Fundamental Relation Between Flux and Magnetomotive Force," may be found in full what was presented at the meeting.

It was Professor Karapetoff's desire to present his new method of nomenclature of things concerned with the magnetic circuit. He repeatedly made analogy between Ohm's Law for Currents

$$C = \frac{E}{R},$$

the Electrostatic Law $Q = CE$, and the Magnetic Flux Law

$$\phi = \frac{M}{R}$$

$$\text{Ohm's Law,—current} = \frac{\text{electromotive force}}{\text{resistance}}$$

Electrostatic Law,—charge = capacity × electromotive force.

$$\text{Flux Law,—flux} = \frac{\text{magnetizing force}}{\text{reluctance}}$$

His belief is that the magnetic circuit is the result of an electric current, and that magnetism should be studied *through* the electric current, and not *before* it.

He introduced many novel terms, such as permittance instead of capacity in the electrostatic equation; to the reciprocal of permittance he gives the term *elastance* with its unit the *daraf*. As the reciprocal of reluctance, with its accepted unit the *henry*, he uses *permeance* with its reciprocal the *yrneh*. These are taken in the same manner as the reciprocal of *resistance* is called *conductance* with its unit the *mho*.

In tabulating his system of nomenclature he spoke of the

	as having	*the material of which it is composed possessing*
resistor	*resistance*	*resistivity*
conductor	*conductance*	*conductivity*
reluctor	*reluctance*	*reluctivity*
permeator	*permeance*	*permeability*
permittor	*permittance*	*permittivity*
elastor	*elastance*	*elastivity*

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The lecture was presented in a most interesting manner by a man thoroughly acquainted with his subject. Professor Karapetoff shows his knowledge of presentation of his subject by having an intermission of five or ten minutes at the end of the first half of his talk, to break the strain of long sustained attention.

On recommendation of the Executive Committee, the following members were unanimously elected:

Active,—

Orel M. Bean, Woburn High School.
W. G. Tucker, Peabody High School.
F. W. Keaney, Woonsocket High School.

Associate,—

Helen Lambert, Lowell High School.

An inspection of the laboratory followed. Those present then availed themselves of the opportunity to take lunch at the Observatory Restaurant, from which a superb view of the Connecticut was possible.

AFTERNOON SESSION.

Central High School.

The afternoon session opened with a piano recital by Professor Karapetoff. This took place in the assembly hall of the High School, and was attended by a large number of persons other than members of the Association. The audience was very appreciative of the explanations and interpretations of Professor Karapetoff, who rendered in fine style the following compositions:

Rubenstein's Kamenoe Ostrow (Stony Island).
Rachmaninoff's Prelude.
Chopin's Heroic Polonaise.
McDowell's Witches' Dance.

The rest of the program was carried out in the Science lecture room.

Mr. Carlton, Assistant Chief Engineer of the Bosch Magneto Company, described the construction and operation of the magneto, and had on the lecture table a dissected sample.

He spoke as follows:—

Before going into detail regarding the construction and operation of a magneto, no harm would be done in showing why the magneto has been adopted as the sole source of ignition by the foremost engine manufacturers of the world.

At the present time, things are only adopted as standard by the process of elimination, and that is, the survival of the fittest. All other types and classes of ignition were tried and found wanting,

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and until the entry of the true high tension magneto into the field of internal combustion engine ignition, there was much to be desired in this line. Records show that as early as 1801, experiments were conducted with a view to utilizing electric current for ignition purposes. Due to the slow progress of the internal combustion engine, nothing further was heard, and practically no progress made until 1860, when the spark plugs were tried and found up to that time, to be the best. The source of current for ignition systems at this time was a battery. In 1870, a man by the name of Markus commenced experiments with a magneto generator. These generators were of the low tension type, and were equipped with oscillating armatures. The current for ignition purposes was being utilized by mechanically operated tappets. Through great changes in construction and method of applying the magneto, we find that in 1892, the first application was made for a patent on a true high-tension instrument, or one carrying both windings on the armature. This development, while due principally to the magneto manufacturers, was also the result of a demand of the motor car builders. They realized that the electrical and mechanical lag present in the systems using the separate coil or the mechanical make and break forestalled any chance of their obtaining maximum efficiency, and, furthermore, were handicapped in putting in the hands of the public, a car which would be simple, and the maintenance of which could be handled by the layman.

An ignition system must be one which is thoroughly reliable under the most adverse conditions,—one which possesses timing range, delivers a hot spark, and still be accessible and simple. As you are no doubt all thoroughly acquainted with the operation of a 4-cycle engine, it is unnecessary for me to describe why advance and retard is required, and therefore, we will start and describe the principle that underlies magnetic operation. Naturally, the instrument relies upon permanent magnets for its source of magnetic lines, these magnets being constructed of a special Tungsten steel alloy, which are heat-treated to a predetermined point, this point having been obtained by extensive tests and experiments. They are given their initial charge of magnetism by bringing them in contact with an electro-magnet. Fastened at or near the bottom of the magnet, are the cast iron pole shoes. These are put there for the purpose of concentrating the lines of force, and directing them in such a manner that they will be most useful. Rotating between these pole shoes is an H-shaped, or shuttle armature, which is built up of numerous pieces of sheet steel, with heavier sections at the end and riveted together as a whole. It is so arranged that this armature revolves between the pole shoes with a minimum amount of clearance. Also, care is taken that the armature revolves in the true centre in relation to the air gaps on each side. On this armature, and next to the core, are wound a few turns of fairly coarse wire, and this winding comprises the primary circuit. One end of this winding

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is grounded to the core, and the other is let out through an insulation in the center of the rear armature.

Taking the instrument as described so far, and causing the armature to revolve, we have a single phase alternating current machine, the principle of which, and the results obtained from which is practically the same as any other alternator, giving two maximums per revolution, providing the armature clearances are alike, and the amplitude of these maximums are the same. Starting with the core in the horizontal position, the magnetic lines of force flow across in such a manner that they are practically all shunted through the armature core or neck, this being the easiest path, and therefore, the moment of the least magnetic disturbance. As we start to move away from the horizontal position, magnetic disturbance commences and increases until a maximum is reached, when the armature core is in the vertical position. Up to this point, the armature neck is strongly magnetized, but its magnetic field dies out as the neck becomes vertical. It is at this point then that the induced current is at its greatest intensity and becomes sufficient for ignition purposes. After moving from the vertical position, we again bring the armature core in such relation to the pole shoes that the path of least resistance is again offered by the armature neck, and this decreases the magnetic disturbance, causing a falling off in voltage, with a continuing decrease until the zero line is reached, when the core reaches the horizontal position. This, you can see, is nothing but a simple alternator, which is delivering a sine curve. This method of obtaining a current, while of sufficient strength to be utilized for ignition purposes, does not leave us with any means of timing the instrument. As synchronous ignition is one of the greatest requirements of ignition systems, and also the fact that the instruments have to be kept of the smallest possible dimensions, there is incorporated on the rear end of the armature shaft, a device known as a circuit breaker or interrupter. The purpose of this interrupter is to close-circuit the primary winding on itself, this close-circuiting to take place at a point at or near the zero line. If not possible to close it at the zero line, close it on a decreasing rather than an increasing voltage. The action that takes place when the interrupter is closed is identical with the action obtained without the interrupter, with the exception that there is a fairly large current built up within the winding itself, and being on close circuit, the potential is very low. The close circuit is maintained to a point where ignition is required, and the instrument is so set in relation to the engine, that when the point of ignition is reached, the armature has also reached a point somewhere within the range of the curve where ample current is present for satisfying secondary capacity. In the full advance position, this armature position would be approximately 1½ to 2 m.m. in distance from the pole shoe. As stated before, in the machine without the interrupter, the maximum pressure

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is reached when the armature core is in the true vertical position. When the interrupter is installed, the maximum current in the armature primary winding is not reached until after the head of the armature has passed away from the pole shoe. There is yet no change of polarity in the direction of magnetic lines in the armature core, due to the fact that the pent-up current in the primary winding is of sufficient strength to hold the lines of force in the same direction as when the armature moved from the horizontal position. At the instant of opening the interrupter, this pent-up current in the armature is discharged. The rush of current that is present at the instant of rupture is taken care of by a condenser. This sudden discharging of the current in the primary winding causes a collapse of this false polarity, and the polarity is re-established in the opposite direction. The two working in conjunction make a very rapid change in flux threading through the winding, and this in turn, gives a violent inductive reaction, which induces in the secondary winding, the same being wound over the primary, an extremely high voltage. There are also two other things to be considered. One, that due to the secondary winding also rotating in the magnetic field, there must also be a current in there due to self-induction. While not very great at the lower speeds, this becomes of quite large proportion in the higher. There is also another condition which helps to build up a current in the secondary winding, and that is, the mutual induction between the two windings. At the change of sine, there is also a change of phase in relation to the primary and secondary, and a portion of the pent-up current in the primary winding of the instrument will find its way or by partial discharge through the secondary winding. By this means we are able to obtain a very high voltage, one which is capable of jumping approximately three-eighths of an inch in the open air.

The turns per secondary are between 7500 and 10,000 turns of .1 mm. wire, and the primary between 150 and 180 turns of .5 to 1 mm. wire.

Mr. Schweier then demonstrated the Maxim Silencer. He briefly told of Mr. Maxim's idea of the Silencer as obtained by watching water swirl as it leaves a bowl through a hole in the bottom. The Silencer consists of a series of aluminum discs so stamped that they produce such a swirling effect upon gases entering the Silencer from the barrel of the gun. In a 22-caliber rifle there are thirteen such discs or chambers. When the smoke and expanding gases leave the barrel each disc divides the entering air stream into two parts, one to go around the disc spirally, the other to pass on to the next disc. The bullet passes straight through the holes that pass through each disc.

The Silencer does not, as one one would expect, eliminate the noise

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entirely; it simply reduces it to a great extent. Bullet flight noise, which is a crack, and not a whistle or whine, cannot be changed.

The Silencer cannot be used on a revolver, as in this the gases can pass out between the barrel and the revolving cartridge holder. Neither can it be used on the automatic pistol, as the noise gets out when the breach opens to let out the empty cartridge. It can be used on a single barrelled pistol.

The Silencer is being adapted as a muffler on autos.

The cost of the Silencer is $5 for the 22-caliber. For higher calibers it becomes $7.00, $8.50, and $9.00, according to the size. It cannot be taken apart, but can be cleaned with hot water, to remove accumulations of smoke.

Mr. Schweier demonstrated with the 22- and the 38-caliber rifles. He used a large box filled half with sand and half with cotton, as his target. Over the half containing the cotton was stretched a piece of flannel. At this he fired. The difference in sound with and without the Silencer was very marked.

Mr. H. L. Washburn, Chief Engineer of the Telegraphone Company, then described and demonstrated the telegraphone, an account of which follows:—

The telegraphone is a device for the recording of sound waves by local magnetism in metal.

We use wire ten thousandths of an inch in diameter in preference to the ribbon or discs which can be used.

The machine has a great many uses, chiefly for the recording of letters, etc., in the ordinary business office. These dictations may be transcribed at any time after being recorded, as time or climatic conditions do not affect the wire. The only way that the records may be destroyed is by equalizing the volume of magnetism in the wire, thus flooding it all together, and the wire is then ready to re-dictate.

We do not have to stop and erase these records as this is taken care of automatically while putting on the new record, thus saving time and never confusing one record with the other.

We also take telephone conversations by attaching our wires to the telephone line; in this way we record both the outgoing and incoming sound waves. The machine itself has many unique features, one of which is that it may be controlled from a distance.

We place the machine in any part of the building and it may be controlled from another room or section, where the dictator may choose.

The solution of the recording of sound waves is based on the discovery that a paramagnetic body such as a steel wire or ribbon which is moved past an electro magnet with an electric or magnetic transmitter, such as a telephone, is magnetically excited along its length in exact correspondence with the signals, messages, or speech delivered to the transmitter, and further that when the magnetically

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excited wire is again moved past the electro magnet it will reproduce the said signals, messages, or speech in a telephone receiver connected with the said electro magnet.

The effect of passing this paramagnetic body past the magnet is to line up the electrons contained in the wire and into different variable strengths, which are affected by the sound waves striking the diaphragm of the transmitter. Scientists have discovered the fact that the diaphragm pressing upon carbon granules used in the construction of the said diaphragm causes a decrease in the resistance.

This is the explanation of the variable resistance caused by talking against the diaphragm.

The sound recorded by this machine is not affected by any mechanical or other foreign sound. Therefore it is very true, and it is easy to recognize individual voices and make corrections of tone, as on a violin or other musical instruments; the player might be self-satisfied but after listening to a record of his execution quite readily detect impressions which would lead him to correct himself and therefore attain another height of perfection.

Following is the report of the

COMMITTEE ON MAGAZINE LITERATURE.

J. C. Moore, *Chairman.*

Electric Journal. February. "The Engineering Evolution of Electrical Apparatus." II. "The Alternating-Current Generator in America." "Experimental Temperature Measurements of Electrical Machines." "Measuring Idle Volt-Amperes." "Shop-Testing of Electrical Apparatus." XIV.

March. "The Engineering Evolution of Electrical Apparatus." III. "Shop-Testing of Electrical Apparatus." XV. "Induction Motor."

April. "George Westinghouse." "The Engineering Evolution of Electrical Apparatus." IV. "Shop-Testing of Electrical Apparatus." XVI. "Single-Phase Transformer."

Electrical World. February 7, p. 324. "Ozone Machines and the Public Health."

February 14, p. 381. "Ozone Machines and the Public Health." These are letters to the editor discussing the subject.

February 28, p. 493. "The Highest Voltage." "The World's Longest Transmission Line."

March 7, p. 522. "An Appreciation of Prof. E. J. Houston." p. 548. "Electricity's Part in a Holiday Celebration." p. 549. "Nitrogen Filled Lamp."

March 21, p. 660. "Portable Pipe-thawing Outfit."

March 28, p. 705. "Electric Arc Welding," rather technical.

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April 4, p. 759, "Color Effects for Advertising and the Stage." p. 747. "Tube Lighting."

April 25, p. 925. "High Voltage Transmission Lines of the World," information charted. p. 36. "Magnetite-arc Units."

Harper's. March. "Dynamic Education." An article on the trade and continuation schools abroad; good.

Popular Science Monthly. February, 1914. "The Physical Laboratory and Its Contributions to Civilization."

April, 1914. "Recent Developments in Weights and Measures in the United States."

School Science and Mathematics. February, 1914. "Graphical Study of Vibratory Motion." "Physical Phenomena Versus Abstractions." "Practical Work in the High School." " An Electrical Convenience." "Method for Determining the Surface Tension of Liquids." "Would a Siphon Flow in a Vacuum? Experimental Answers."

March, 114. "Failures in Physics at the College Entrance Examination Board—The Causes and Remedies." "The Problem of the Loaded Table." "On the Quantum Theory of Light." "A Halo and a Rainbow."

April, 1914. "Verifying the Laws of the Pendulum." "A Useful Pendulum, and a Simple Wireless Method for Velocity of Sound." "An Experiment on the Expansion of Water." "On the Quantum Theory of Light" (concluded). "Graphical Representation of the Error in Mirror Formulae."

Scientific American. February 7. "Let the Sun Supply Hot Water." "Highest Dam in the World." "Condensation of the Moisture in the Atmosphere."

February 14. "Watching the World Revolve."

February 21. "A Quick Acting Thermopile."

February 28. "Stopping Express Trains in Their Own Length. "How's the Weather Up There?"

March 7. "Water Spouts."

March 14. "Bucking the Ice of the Great Lakes with a Gyro Automobile Headlamp." "The Storm of March 1, 1914, Measured in New Units."

March 21. "Kodak Film Case." "A Remarkable Hack-saw Test."

March 28. "George Westinghouse."

April 4. "Gravitation and the End of the World." "Most Powerful Government Wireless Plant at Radio, Virginia."

April 11. "A Great Telescope for Canada."

April 25. "The Man at the Switchboard." "Water-power Pumping Plant of Paris."

Scientific American Supplement. February 7. "The Crooked River Arch."

February 14. "Progress in Locomotive Design."

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February 28. "The Industrial Need of Technically Trained Men." "The Shaw Electric Measuring Machine."

March 7. "Some Phenomena of Fluid Motion." "The Industrial Need of Technically Trained Men." "The Black Warrior River Lock and Dam." "A Canadian Suspension Bridge."

March 14. "The Industrial Need of Technically Trained Men." "Novel High Tension Voltmeter" (Siemens and Halske). "Wireless Telegraphy before Marconi."

March 28. "Our Present Knowledge of X-rays."

April 4. "Man as a Source of Mechanical Power."

April 11. "Selecting a Prime Mover." "Marconi Wireless Suit." "Pyrometer for Superheated Locomotives."

April 18. "Comparison of Rivers." "Cost of Electricity at the Source."

April 25. "Recent Discoveries in Physical Science." "Electric Emissivity of Matter."

Technical World. January. "Taking the Heat Out of Light."

February. "The Wireless on Board Train."

April. "Within a Tick of the News."

May. "Great Scientists—A. A. Michelson."

World's Work. The chapter on "Man and His Machines" in the numbers for February, March and April, is good.

Following is the report of the

COMMITTEE ON CURRENT EVENTS IN PHYSICS.

Emerson Rice, *Chairman.*

The impending war with Mexico may have a tendency to boom the study and practical application of aeronautics by the United States Government. Our government is considerably behind other nations of the word in the strength of its air fleet. In the past five years Congress has appropriated for aeronautics $435,000, while Germany has spent $28,000,000, France $22,000,000, Russia $12,000,000, Italy $8,000,000, and England $5,000,000.

One practical example of the possible importance of aeroplanes in military operations is given in the *Boston Transcript* of April 25, by a description of the work of the aviation corps attached to the military station at San Diego.

Two Burgess tractors went out 25 miles, and in 53 minutes were back at headquarters with a detailed report of the location and line of movement of a body of troops sent out secretly the day before. It was calculated that it would have taken the cavalry at least two days to have obtained this information. At present the United States has only ten effective aeroplanes available for such work, four in the army and six in the navy.

The *Boston Transcript* of April 25 contains a description of three-

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of the largest turbines in the world, which are being constructed for the Interborough Rapid Transit Company of New York, representing the last important engineering work of the late George Westinghouse.

Each of these turbines are to be connected to dynamos delivering 30,000 kilowatts, or about 41,000-horsepower.

They will occupy about one-fourth the floor space of the reciprocating engines necessary to deliver the same power. Each unit will use about 350,000 pounds of steam per hour, at 200 pounds pressure, superheated to 120.°

Fifty thousand square feet of cooling tube surface will be installed with each turbine to condense the steam which is saved and returned to the boilers. Salt water is to be drawn from the East River and circulated through these pipes, 4,500,000 gallons being pumped to each condenser every hour, more water than all of New York is getting for other purposes from its Croton supply.

The saving in coal is expected to be considerable. The old machines had a thermal efficiency of 17½%. These new turbines are expected to work at a thermal efficiency of at least 25%, a higher rate than ever before attained in a commercial machine.

In the *Scientific American* of April 18, 1914, we find a complete and interesting description with diagram and photographs of a "Remarkable Development in Kinematography." Moving pictures are projected by reflection from the wings upon the stage, with the elimination of the usual white screen, in such a way that the stage may be set with scenery and properties and the illusion conveyed of living performers instead of photographic reproductions. When a talking machine is electrically synchronized with the projecting apparatus the illusion of a real play is complete, and when presented at the Scala Theatre in London, the whole presentation met with instant success. The absence of the usual white screen is very attractive and the usual flicker of these pictures seems to have been entirely absorbed by the translucent screen used in the projection apparatus.

The use of powdered coal as a fuel seems to have been developed to a very successful practice until it possesses not only all the advantages of a burning oil spray, which it resembles in many ways, but also considerably greater economy.

The coal is first dried till it contains not over one per cent. of moisture; it is then pulverized to a high degree of fineness; then it is blown into a chamber hot enough to insure instant deflagration, where it is supplied with air sufficient to burn the carbon at once to carbon dioxide. All the arrangements necessary for these processes are fully described and illustrated in the *Scientific American* of April 18. The comparison of this fuel with oil, gas, and common coal in thermal value and cost is also given in the article and will

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be found to greatly favor this powdered coal burning in jets like oil.

A spirited voting contest has just been completed in Germany in which a large volume of votes was cast and counted, to decide which are the seven wonders of the twentieth century. The result of the balloting placed wireless telegraphy first and the Panama Canal second. The five others follow in order: the dirigible air ship, the flying machine, radium, the cinematograph, the steamship *Imperator*.

Sikorsky's huge biplane, the largest heavier-than-air craft ever constructed, has been continuing its record-breaking passenger flights in Russia. Its latest achievement has been a journey lasting eighteen minutes with sixteen persons on board. In all, a useful load of more than 2800 pounds, or nearly a ton and a half, was raised from the ground, in addition to the weight of the machine itself, which is 7700 pounds. Altogether, therefore, the *Ilia Murawetz*, as the craft is called, lifted more than five tons.

New Orleans boasts a thermometer ten feet high. It contains one gallon of mercury.

A new wireless receiver reflects the wireless flashes from a mirror.

The largest telescope for photographic purposes exclusively is now on its way to America for use in Allegheny Observatory. Its diameter is 30 inches.

A magnet of remarkable power was recently exhibited in France. The windings are made of very thin metallic ribbons, cooled by a circulating bath of gasoline at low temperature. It produces 52,000 units.

The meeting closed with a unanimous vote of thanks to our hosts of the day.

Considering the fact that the meeting was held so far from Boston, the number that attended the meeting was unusually large. It is to be regretted, however, that more of the members around Boston did not make greater effort to take the trip, since our members from the western part of the State have been pretty regular in their attendance, and this was a chance to show our loyalty.

ALFRED M. BUTLER, *Secretary*.

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PROGRAM OF THE SIXTY-NINTH MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, December 12, 1914

AT

at the Newton Technical High School, Newtonville, Mass.

9.30 A. M.
Meeting of the Executive Committee.

9.45 A. M.
Business Meeting.

Reports of Standing Committees:

On New Books. Clarence Boylston, Chairman.

On Magazine Literature. J. C. Moore, Chairman.

On Current Events in Physics. Emerson Rice, Chairman.

On New Apparatus.
Mr. C. B. Harrington of the Newton Technical High School will show several pieces of apparatus.

10.45 A. M.
"A Sabbatical Year's Experience in the Industries." C. S. Griswold, Groton School.

11.30 A. M.
Vice-President's Address.
"Efficiency and Equipment of a Physics Teacher." Homer W. LeSourd, Milton Academy.

12.00 M.
Discussion of the papers of the Morning Session and of the preceding night's Smoker.

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THE SIXTY-NINTH MEETING.

The meeting was called to order by President Timbie, who called on Mr. Boylston for the

REPORT OF THE COMMITTEE ON NEW BOOKS.

Mr. Peterson read the following review of

"HOUSEHOLD PHYSICS."

By A. M. Butler, Head of the Science Department, High School of Practical Arts, Boston, published by Whitcomb and Barrows, Boston.

The title of this book, "Household Physics," may give the impression that it is a text-book for girls only. Such is not the case. The word "household" is used in its broad application. The book is a practical text-book in physics suitable for either girl or boy and could be used as a basis for preparation for college.

The impression as to make-up, type and illustrations is of the best. The cuts are actually new, not drafted from some other book by the publisher. There are 349 of these and they are without exception excellent, especially those on light.

The order is unusual and is one of the new and good features of the book. It is true that some will exclaim in horror, "Mechanics last and heat first!" Have you tried beginning the subject of physics with heat, the best known and most interesting of the topics studied? If you have not, try it some year and note the excellent results of immediate interest. As a biologist said concerning this order: "The old way of beginning with mechanics seems to me like the discarded method of beginning physiology with bones."

Some will miss the usual mathematical problems of which this book contains comparatively few. There are many who agree with the author that "there can be just as good mental training in developing the thought that enables a pupil to answer a set of questions selected from every day experiences as can be obtained from the ability to solve a mass of difficult problems." Instead of mathematical problems there are a large number of unusually fine thought-producing questions on the applications to daily life of the principles learned. They are live questions, such as will be appreciated by the pupils and the parents. Many believe that physics has been made too mathematical, with the resultant omission of the real life,—of that which gives meaning to the subject. Those who use this book and who desire more mathematical problems than it contains can use some good problem book.

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As the name of the book implies, the practical side of the subject is emphasized,—and far more than in some of the recent books whose titles would lead one to expect more than one finds. The practical illustrations are unusually well selected from those objects and phenomena best known to the pupils, in their intimate daily life, so that they can immediately visualize them and therefore understand the principle more easily. These illustrations both precede and follow the discussion of the principle, in the first instance by way of introduction, and in the second to clinch the principle.

The features of this book, then, are: introducing the subject with the interesting topic of heat, the inclusion of an unusually large number of well-known practical applications, the substitution of every-day thought-producing questions in place of most of the usual mathematical problems, and the simple and clear text. The result is that Mr. Butler has produced an excellent, interesting, scientific, up-to-date book, just such a one as is needed for many classes in general physics.

Mr. Boylston then read a review of the three following books:—

"Elements of General Science."

By Otis Caldwell and William Eikenberry of the University of Chicago. Published by Ginn and Company. 308 pp., 137 illustrations.

The authors admit the difficulty of deciding upon an ideal course for general science. This book embodies their ideas as to what it should be.

The subjects are grouped under five heads, contained in 31 chapters. Part I consists of 9 chapters on The Air,—physical properties, changes of temperature and of seasons, water of the air (the weather composition), relation to food-making going into the function of the leaves of plants, and chlorophyll, photo synthesis, etc., dust molds and bacteria, disease germs, life history of house flies and mosquitoes. Part II. Water and Its Uses. Five chapters,—ice, water and steam, water pressure, influence of bodies of water on climate and commercial relations, water supply and sewage. Part III, 3 chapters on Work and Energy. Part IV, 5 chapters on The Earth's Crust, especially with reference to the soil. Part V, 9 chapters on Life upon the Earth, including plant and animal life.

The book certainly deserves the name General Science. A teacher using it would need to possess a. wide knowledge of the various branches of science, and to be an enthusiast in them all.

"Physics of the Household."

By Carleton John Lynde, Ph.D., Professor of Physics in Macdonald College, Canada. Published by Macmillan Company. 1914. 313 pp., 217 cuts and illustrations. Price, $1.25.

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The book presents hundreds of the applications of physics to household affairs, in a simple and interesting way, some of the chief ones being clear and simple diagrams of plans for pneumatic tank system for country homes, hydraulic ram, vacuum cleaners—hand driven and motor driven, fire extinguisher, traps, gas meter, drafts in stoves, furnaces, etc., diagrams of all the parts of a cooking range, different systems of heating (hot air, hot water, and steam), hot water tank connections, thermos bottle, fireless cooker, methods of ventilation, refrigerators, household electric heating and cooking appliances, plan of the entrance of electric wires into a house, with switch, meter and fuses. Although adapted to the requirement of beginners, those who have previously studied physics will welcome the concise review of principles and the many applications and illustrations. It would seem to be adapted to the requirements of a domestic science course or such work in physics as would appeal to students in a general course.

"Handbook of Chemistry and Physics."

A ready reference pocket book of chemical and physical data. Compiled from the most recent authoritative sources. Published by the Chemical Rubber Company, Cleveland, Ohio. Contains over 300 pp. of data tables, and information of value to the chemist, physicist and student. Price, $2.00, but will be furnished to students and teachers at $1.00 while this edition lasts.

Through unforseen circumstances the report of the Committee on Magazine Literature could not be written. The report will appear in the report of the next meeting.

Following is the report of the

Committee on Current Events in Physics.
Emerson Rice, *Chairman.*

Using a new aeroplane gun, United States army officers, flying at a rate of nearly a mile a minute, 600 feet in the air, have made more than 90% of hits on a small target on the ground.

One Y. M. C. A. branch in New York has a new sterilizing system for swimming-pool water which allows the latter to be used almost indefinitely. Ordinary filtration takes away impurities in suspension, then the water is passed through an apparatus where it is exposed to ultra-violet rays. These kill a large proportion of the germs, including all intestinal germs. Two 220 volt, 2.2 ampere mercury-vapor lamps furnish the ultra-violet rays.

John Hays Hammond, Jr., recently gave a very successful demonstration of his radio-controlled boat, the *Natalia*, before a special

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commission of army officers. Sitting at his controller in the laboratory at Gloucester, he was able to change the course of the boat at will and had absolute control of it within a radius of eight miles. This was with only a 5 kw. station, whereas battleships carry stations of 30 to 50 kw. An important improvement in the apparatus is a device for preventing interference with his control by an enemy's station of higher power. Applied to a torpedo, this invention will be of immense value for coast defense as well as for attack.

On the night of April 21, 1914, the Pacific Mail Steamer *Mongolian* exchanged messages with Boston, 8500 miles away. This makes a new wireless distance record.

A Portugese-American claims to have produced a new motor-car fuel which is cheap and efficient. Naphthaline, water, and a third unnamed ingredient are passed through a still and produce a liquid resembling gasoline.

On May 1, 1914, Prof. R. A. Fessenden, on the tug *Neponset*, off Boston light, made a satisfactory test of his invention of submarine signaling. The Metropolitan Coal Company's collier *Devereux* started signaling on rounding Cape Cod and the Morse code signals were immediately picked up.

Mirrors are now made by electrical deposit of silver on glass. The silver plate is pressed closely to the glass, and the plates are placed in vacuo into which a little hydrogen gas is admitted. Other metals may be used in place of silver. A high potential current is used.

A lock-out device has been perfected for telephones which is said to insure privacy in their use.

The war thus far has demonstrated that the offensive in submarines, air craft and big guns has outstripped defensive developments.

Flying boats with folding wings and a ship especially designed to carry them are building in England.

A six-pound non-recoil gun for use in aeroplanes is open at both ends; one end discharges harmless shot at low velocity, the other the projectile.

Twenty-four ocean-going steamers are now equipped with engines of the Diesel type, and progress is being made in overcoming difficulties. Air compressor troubles are most numerous.

Recent moving picture cameras utilize a magnesium-aluminum candle for underground work in mines and caverns. For it is claimed a constant white light up to 50,000 c.p., and of constant actinic violet ray. Its penetrative power is said to be 1000 feet.

A gyroscopic stabilizer for aeroplanes is said to make the air craft foolproof. The stabilizer weighs forty pounds, and occupies a space of 18 inches wide by 12 inches high. The four gyroscopes, each 2⅞

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inches in diameter, work in pairs. one pair controlling fore-and-aft, the other lateral balancing. The rotation is at the rate of 12,000 R.P.M.

Mr. Harrington of the Newton Technical High School then demonstrated a form of rotary convertor put out by the Holtzer Cabot Company, for purposes of laboratory study of direct and alternating current. It may be belt driven and used as a generator of direct or alternating current. From it at full speed may be taken a one, two or three phase alternating current, of 80 volts for the one phase, to 60 volts for the three phase, or 110 volts direct current. Electrically driven it may be used as a direct current motor or as a synchronous motor of one or three phases.

It is a compound wound machine, from which the series and shunt windings are brought out separately. On a switchboard connected with it, each wire of the machine has a terminal. To these, plugs may be attached to allow of any system of connecting. In this way the student need not unscrew any wires at the machine.

To use it as a belt driven generator a variable speed motor is furnished. It has interpoles in the field, and is started by means of a starting box with a series of resistance coils.

If the convertor is driven by direct current, a one, two or three phase alternating current may be taken off. When run as a one, two or three phase synchronous motor, direct current may be taken off. It yields an efficiency of about 72%.

By use of a transformer, which forms a part of the outfit, the alternating current voltage may be stepped up or down, so as to show the relation between the efficiency of high and low voltage transmission in lines.

The convertor, when belt driven, and with separately excited field, shows very plainly the dependence of induced E. M. F. upon rate with which lines are cut.

It may be used to show hysteresis, magnetic lag, and efficiency as a D. C. and A. C. motor under different loads.

Mr. Harrington showed some interesting slides of curves as obtained by some of his pupils.

Mr. Hall showed a modification of the Knott cups (black and nickeled) for showing rate of radiation from rough and smooth surfaces. Instead of exposing the small cup directly to the air, an outside nickeled cup is used, so that air currents may not act unequally on the two cups.

He also showed an electric rotator. This consists of a small series wound motor that is ball bearing and has a universal joint, so that it may be clamped in any desired position. Being series wound it will run on a direct or alternating current. The shaft is of the same diameter as the hand rotator, so that all regular attachments can be used on it.

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When running at slow speed as in rotating the globe of water, it takes 2.2 amperes A. C. at .7 volts. For the color discs it takes 4.15 amperes D.C. at 2.4 volts. With axis vertical for rotating a chain loop, it takes 3.5 amperes at 1.2 volts.

Both of the above pieces of apparatus can be bought of the Cambridge Botanical Supply Company.

On recommendation of the Executive Committee the following were unanimously elected members of the Association:—

Active:—

J. D. Danforth, Beverly High School.
R. S. Haggard, Newton Technical High School.
W. E. Robinson, Boston Latin School.
M. Kane, Trade School, Worcester.

Associate to Active:—

G. A. Cushman, English High, Boston.

Mr. C. S. Griswold of Groton School then gave an address on

"A Sabbatical Year's Experience in the Industries."

Leaving home in November, he spent the rest of the school year in traveling about the United States, visiting schools, colleges, observatories, mines, smelters, rolling mills, automobile manufactories, and locomotive works. The first month was taken up in studying iron, *i.e.* the operations of drillings, and mining for iron in the Mesaba and Gegebic districts in Michigan, followed by a visit to the smelters and rolling mills at Gary, Ind., and concluding with a ten days' visit to eight auto manufactories in Detroit. These visits were described briefly. The two experiences which he described in most detail as being of more interest to the members of the Eastern Association of Physics Teachers were his visit to the Lick Observatory at Mt. Hamilton, Cal., and his six weeks' experience as student guest of the Union Pacific Railroad at Omaha.

Of his visit to the Lick Observatory he said:—

"Through the kindness of influential friends, one of whom has financed most of the Lick undertakings of late years, I was given a cordial welcome at the Observatory, and every effort was made to make my three days' stay pleasant and profitable. The approach to the Observatory is impressive. We motored up a winding road thirty miles long from San José to the summit of Mt. Hamilton, getting beautiful glimpses of mountain scenery en route. At dusk the first evening the top of the mountain was covered with a curtain of cloud. At nine o'clock this cleared away, permitting me to have one of the most interesting experiences of my life, sitting with my eye to the great telescope for three hours, with the Director, Dr. Campbell,

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beside me, telling about the stars and the work his little band of eight astronomers was doing."

Of late years the Lick Observatory has confined itself to finding the radial velocity or motion in the line of sight of the stars. Twenty-three years ago the velocity of not a single star was known. Today, although the distance of only about one hundred stars is known, the Lick observers have worked out the velocities of over one thousand stars, verified the rotational velocities of the sun, the planets, Saturn's rings, and the double discovered visually, and discovered and ascertained the periods of rotation of about four hundred double stars, one or both of which are invisible to the telescope. They have also computed the mean velocity of all the stars to be about 40 kilometers a second, individual velocities ranging from 6 to 250 kilometers a second.

Newcomb, assuming the number of the stars to be about one hundred million, with an average mass four times that of the sun, occupying a space of 15,000 light years, maximum diameter, computed that a body starting from Infinity, with zero velocity, entering the universe of stars, would have a velocity of 20 kilometers a second. The Lick Observatory and others through photographs add two hundred more million to the number of stars, and the spectograph adds many more, all of which seems to explain the greater actual velocity over the computed one of Newcomb.

The achievements of the Lick Observatory are due almost entirely to the application of Doppler's principle to light, combined, of course, with the splendid 36-inch Clark lens, the Mills spectograph, and the services of an unusually able corps of astronomers assembled from all over the world. Here the Doppler principle, as modified and adapted to the problem, was explained.

Mr. Griswold next described his experience in railroading:—

"Through the kindness of Mr. Harriman I was made *persona grata* at the Union Pacific headquarters at Omaha, Neb., and almost literally in the words of the President, Mr. A. L. Mohler, was allowed 'to have and to do anything he wanted.' I told them that I wanted to learn all I could in six weeks about the fabric and mechanics of a big railroad system, and was given advisers to help me plan a suitable campaign for doing it.

"In line with the advice of these gentlemen, I entered the Railway Kindergarten, by name the 'Railway Educational Bureau.' This is an institution begun by Mr. Harriman for the purpose of giving quick and thorough instruction in any and all matters pertaining to all departments of railroading. It operates along the lines of the Scranton Correspondence School and numbers among its pupils railroad men all over the United States.

"I was favored in not being obliged to get the instruction through the slow process of correspondence, but was given a desk in the office,

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where I spent the forenoon of every day for a month studying the 'Units' published by the School. These units are small pamphlets of from twenty-five to fifty pages, covering such subjects as 'Locomotive Boilers,' 'Boiler Appliances,' 'Combustion and Firing,' 'Practical Locomotive Firing,' 'The Locomotive,' 'The Air Brake,' 'Steam Engine Indicators and Diagrams,' 'Track Work,' 'Ties and Tie Plates,' 'Block and Interlocking Signals,' and many other subjects in the different departments of railroading.

"The afternoon of each day I spent in applying the information obtained from the 'Units' in working in the round-house, machine shops, wrecking shop, in Omaha, and the freight yards at Council Bluffs. As I wanted to get as much practical first hand knowledge as possible, I was allowed to fire, get up steam, and run engines of various types, from the little saddle tank switch engine to the Majestic Pacific Type Superheater. I was first given practice in driving engines in the switching yards at Council Bluffs, varied with short runs on branch lines, until the grand occasion when I made my debut, so to speak, by running a train of eight passenger cars, in full charge of the engine, from Omaha to Grand Island, a distance of 150 miles,—a most fascinating and exciting experience for a tenderfoot.

"In all I drove engines 500 miles, and rode engines 1600 miles, concluding with the long run engine-riding of 1000 miles from Omaha to Ogden, en route to the coast, where after spending a week in studying the oil-burning engines of the Southern Pacific Railroad, I graduated from my special course in the great University of the Railroad, impressed with the interest, the reality, the intensity and momentum of railroad life."

Mr. Griswold also showed several charts showing how the Bernouilly Principle might be used to explain a number of common but puzzling phenomena. This Principle is that a faster moving fluid exerts less pressure than does a slower moving one. He used it to explain how the *Olympic* and *Hawke* were drawn together and collided broadside; the ball that hangs on the side of a vertical jet of water; the card at the end of a spool.

NOTE.—A more detailed discussion of this may be found in an article by William S. Franklin of Lehigh in *School Science and Mathematics* for January, 1911.

Our Vice-President, Homer W. LeSourd, then gave an address on

"EFFICIENCY AND EQUIPMENT OF A PHYSICS TEACHER."

Significant and far reaching changes have come to pass in the industrial world in the past ten years; changes which the physics teacher, because of his training and interest, can appreciate and understand. The term "efficiency" has acquired a broader content. The worker, as well as the machine he operates, has a definite

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efficiency and the plant as a whole, men and machines together, has also its efficiency. Since efficiency can only approach 100% as wasted effort approaches zero, it is the business of the efficiency engineer to eliminate waste,—waste of time, of material, of design, of effort, of administration,—in a word, waste of inefficiency. Works management has become a well-formulated science with principles, methods and data which have found application in many of the largest manufacturing and operating establishments in this country.

Some of the fundamental principles of this science are as follows: Substitution of machinery for manual labor wherever possible, standardized equipment, standardized location of equipment, maximum output for each machine, motion study of the worker, proper environment for the worker, utilization of by-products. The responsibility for planning the work lies with the "staff," while the worker follows directions to the letter. However much we may deplore the tendency to thus make a machine of the worker, we cannot fail to appreciate the scientific methods employed by these founders of our latest science and the remarkable results they have attained.

The physics laboratory in its equipment resembles both office and factory and the physics teacher combines the function of educator, factory manager, machinist, electrician, carpenter, plumber and factotum. The preparation of experiments consumes much time and requires some ingenuity. School authorities have for the most part still to learn that the teacher of science cannot carry as many hours of class room work with efficiency as teachers of most other subects. The science teacher needs time to arrange the workshop of his class, time to repair, clean, arrange and replace apparatus, time to clean up what pupils and janitor will not, time to arrange lecture experiments, time to build apparatus with the help of his pupils, time to read current scientific literature, time to foster a science club for collecting pictures and illustrative materials, time to conduct excursions to factories, etc. These are activities which yield large returns on the time and effort invested, but time is not always to be had. We will venture to suggest some simple expedients by which the overworked science teacher may economize time, may eliminate wasted and misdirected effort, may apply advantageously the principles of industrial efficiency to his daily routine.

Fortunate is that science teacher who has acquired the fine art of making plans for others to execute. The paid or volunteer student assistant, if properly chosen and frequently advised, relieves the teacher of a large amount of purely mechanical labor in the manufacture and care of apparatus. The manual training department, in many schools, contributes much well-built apparatus, and the business department gives valuable assistance by supplying instruction sheets for laboratory work and other typewritten matter.

In most schools the time allowed for physics recitations and lectures is inadequate, and consequently every second is valuable, yet

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often in the midst of a lecture we struggle for a long time with refractory apparatus which should have been adjusted in advance or make an extended search through cases and drawers for some missing apparatus while the class, more or less patiently, waits. Such inefficiency and mismanagement would not be tolerated in any modern industrial plant. A recitation with demonstrations will be a success only when it is carefully planned in advance, a written outline of topics and experiments prepared, and each piece of apparatus so well trained to perform its part that there can be no chance for delay or failure. Many are the devices and conveniences which contribute to this perfection of technic. Of prime importance is a properly equipped lecture table with outlets for water, gas, electricity and compressed air. Near at hand, literally within reach, there should be drawers for the storage in orderly shape, of corks, tubing, wire, connectors, etc., which are in such constant demand. These drawers should be small enough to be easily opened with one hand. The science teacher has much to learn from the skillful surgeon or dentist as to the convenient location of tools and instruments for "one-handed" use.

Physics teachers, in general, have not been slow in recognizing the advantages of standardized equipment and interchangeable parts. Lecture table adjustable supports, the adaptable projection lantern, the optical disc, the rotator and accessories, and the P. E. D. electrical outfit are worthy examples of the apparatus makers' contribution to lecture table efficiency.

To the credit of the American manufacturer it has been said that he will discard a costly machine in A-1 condition if one of more recent pattern will better serve the purpose, and the teacher who finds defective antiquated equipment in his laboratory is justified in taking similar measures. Moreover, there are certain tools, such as screwdriver, pliers, wrench, etc., which are in frequent use both at the lecture table and in the shop, and duplicate sets of these tools should be provided for exclusive use at each place, thus saving some miles of needless walking for the teacher each year.

In the Ford automobile plant some years ago an investigation of floor plans and distances was conducted and the location of machines changed to facilitate the orderly, effective and economical progress of work from machine to machine. Prior to that investigation the four-cylinder casting travelled no less than 4000 feet in course of finishing; that distance has now been reduced to about 334 feet. Similarly, a study of the problem of size, proportions and location of lecture room, laboratory, apparatus room and shop would result in the reduction of needless journeys from point to point and a consequent economy of time and effort.

The area directly behind the lecture table is a centre of activity and around it lie "zones of availability," to be considered in the storing of apparatus, tools and supplies; those things most frequently

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used being placed in the most accessible positions. This is the common practice followed in the stock rooms of factories. The orderly arrangement of apparatus in cases obviously contributes to the efficiency of the teacher. Its effect on the pupil is less obvious but no less real. Orderly thinking is promoted by orderly arrangement and it is significant that data compiled by efficiency experts prove that a crowded or cluttered work room materially reduces the quantity and quality of work done and causes fatigue to the worker. Many a laboratory has a stock room which through years of neglect has become a junkheap with a haphazard distribution of metal, lumber, rubber and glass, which only one person can remember and which no one can explain. Such a stock room is worse than useless.

In the preceding discussion we have attempted to show how the science teacher may apply certain principles of efficiency by maintaining a business-like organization of the way in which apparatus, tools and supplies are handled, stored and manipulated. No less essential to efficiency in lecture room and laboratory is the desk work done by the teacher in his own library in preparation for his class-room work. It is here that he plans the day's work, reads current scientific literature, collects pictures and clippings which will stimulate scientific interest in the pupils, and prepares the outline of procedure for each recitation. The card catalogue and vertical file, which have contributed so much to office efficiency, will prove equally valuable to the science teacher; the card catalogue for preserving addresses, books and apparatus lists and references to articles of interest in books and periodicals; the vertical file for preserving clippings, pictures and notes in convenient form.

The meeting closed with a vote of thanks to those in charge at the Newton Technical High School.

Forty-five members gathered at the annual smoker held on Friday evening at the City Club. Mr. N. H. Black introduced the subject of discussion by reading from a letter sent him by Mr. Packard, who was unable to be present. In substance Mr. Packard wrote that he looked upon college entrance examinations as necessary evils in the East, and looked forward to the time when they would be done away with, even as they are already in the West. He suggested that in the meantime it might be well to make it possible for a larger number of science teachers to have a hand in framing the questions, by submitting questions to the Board. He further brought out the idea as to whether or not the personnel of the Board should change occasionally. The possibility of making the questions accord with the new ideas as to the best way of teaching physics (through those things that are close to the pupils' daily life) was suggested. He criticized certain questions on both the College Entrance Board and Harvard papers as being too academic, and not real live problems.

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He objected to being tied down by the colleges in the experiments the pupils must perform, considering it in the same light as that of dictating a text-book.

With this as a beginning, there was discussion in plenty for nearly three hours. Professor F. A. Waterman, Chief Examiner of the College Entrance Board, set forth the side of the Examiners, explaining in detail how the questions were based on the Syllabus, copies of which were placed in the hands of all teachers. This Syllabus was last revised in 1909. The Board, in making up the examinations, finds great difficulty in selecting questions that will meet all conditions. As a result of the difference in teachers and facilities, there is always considerable option in answering the questions. There are problems before them always. Should the examination test the fitness for admission by placing emphasis on information as such, or on the power to reason and apply knowledge: While the latter may be the correct point of view, it will not work out in the majority of cases. Questions of such a nature are often misunderstood, as the teaching has been of a conventional form. The power to reason is undeveloped in such immature minds, where the training in physics is not long and exhaustive. He ended by saying that the examiners are anxious to hear criticisms and to profit by them, so that the papers may be perfected thereby. Specific illustrations of the present troubles will greatly aid them in changing the form of questions.

In the course of subsequent questions and discussion, Professor Waterman brought out the following facts:—

The rating for each question varies, and is decided upon before correcting the books by the readers in conference (five in 1914).

The book is read by one reader. If failure, a second reader rates it independently of the first. One-third of the books are rated under 60%.

The passing mark is determined by the individual college; some as low as 50%.

The rating for laboratory work and note book is determined by the individual college.

Harvard, Chicago and Smith make a distinction between pupils who have used physics for entrance and those who have not so done.

The physics course as outlined in the Syllabus has been arranged by secondary school teachers, who constitute the Board.

Pupils select a mathematical problem in preference to a practical one requiring even simple reasoning, and fail in it, probably because they think they know it. An instance of memory versus reason, showing a mechanical preparation.

Reasoning questions are to be preferred; but they could not be answered by many, as there is a great lack of competent teachers.

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From the teachers present came the following expressions:—

Most who expressed themselves believed the papers of 1914 very fair and satisfactory.

Why not have two groups of questions, one set purely mathematical and the other practical?

There is too little time to cover the subject properly. One subject must be omitted. This subject is Sound, which in some cases is done outside school hours.

The course as at present is not fit for girls, whose minds are not so practical.

Dr. E. L. Chaffee and Prof. H. N. Davis of the Harvard Entrance Board represented the college side of the Harvard examinations. In the course of his remarks Dr. Chaffee noted the following:—

Formerly the laboratory examination and the paper were each 50%. This is not so now. A very poor examination in either may throw a pupil out.

The note book does not receive a point credit. It is taken into consideration as part of the laboratory examination, but receives only a casual inspection. The examiner endeavors to make a mental note of the book in his examination of the pupil.

There should be no limit to the length of time allowed for answering the questions on the paper, as some minds are much slower than others.

Professor Davis desired to know what the teachers wanted Harvard to do.

Those present brought out two points most emphatically. One was the lack of time in answering the paper, and the other was the attitude taken by the pupil in the matter of note book importance. The feeling has spread among pupils who have taken the laboratory examination that the book was not even looked at; several tests having been made. These instances occurred some time ago, before the present system went into effect apparently, for in one instance it was shown that a number of boys were, through an error, failed on account of their note books.

It was suggested that the time allowed for the written examination be extended, and that note books be returned with some remark, such as accepted, meager, insufficient premises, etc.

The question of being required to teach the absolute units, such as the dyne, erg, joule, etc., which was the subject of a very heated discussion several years ago, again came up. A vote being taken, 31 registered against it while 8 were for using them.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SEVENTIETH REGULAR MEETING

OF THE

Eastern Association of Physics Teachers

THE LIBRARY

Saturday, March 20, 1915

at the Medford High School, Medford, Mass.

9.45 A.M.
Meeting of the Executive Committee.

10.00 A.M.
Business Session.
Report of Standing Committees.
Election of New Members.
Election of Officers.

11.00 A.M.
Prof. E. Grimsehl: Qualities in his character which made him universally loved and esteemed. Mr. N. Henry Black.

A Symposium on the Subject:
"WHAT SHOULD BE THE AIM IN HIGH SCHOOL PHYSICS TEACHING?"

11.30 A.M.
From a Religious Point of View. Dr. Charles F. Dole, President of the Twentieth Century Club.

12.00 M.
From the Point of View of the Laboring Man. Mr. Henry Abrahams, Secretary of the Central Labor Union.

12.30 P.M.
Luncheon: Served by the Domestic Science Class at the High School. Inspection of the Laboratories.

1.30 P.M.
From the College Point of View. Dr. Hermon C. Bumpus, President of Tufts College.

2.00 P.M.
From an Engineer's Point of View. Dr. Gardiner Anthony, Dean of Tufts Engineering School.

2.30 P.M.
Summary of the Discussion. Arthur L. Williston, Principal of Wentworth Institute.

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MORNING SESSION.

The meeting was called to order by President Timbie, who called for the

ANNUAL REPORT OF THE SECRETARY.

During the past year there have been the customary three regular meetings, with a smoker on the evening before the fall meeting. The annual meeting was held on March 7, at the High School of Practical Arts, in Roxbury. This was the only meeting held in Boston. Mr. Charles P. Frey of the Weston Electrical Instrument Co., gave some very interesting and illuminating information in regard to the Weston pamphlets and Weston instruments. Mr. Butler briefly explained the Westinghouse Air Brake, by means of large colored charts.

On May 9, we were the guests of Mr. Hall at the Springfield High Schools, spending the morning in the Technical High, and the afternoon in the Central High. Here we listened to a lecture by Professor Karapetoff of Cornell, on the "Magnetic Circuit." In the afternoon, Professor Karapetoff gave a piano recital in the assembly hall.

On December 11, at the Boston City Club, we had our annual smoker. The subject of the evening was a discussion of college entrance examinations. With Professor Waterman of Smith College, and Professor Davis and Dr. Chaffee of Harvard, to represent the examiners, a lively discussion took place.

The smoker was followed on December 12, by a morning session at the Newton Technical High School. Mr. Griswold told us of his Sabbatical year in the West, and Mr. LeSourd delivered the vice president's annual address. His subject was "Efficiency and Equipment of a Physics Teacher."

The present membership is eighty-four active and sixty associate, an increase in active, but a slight decrease in associate members.

Respectfully submitted,

March 20, 1915. ALFRED M. BUTLER, *Secretary.*

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This was followed by the

ANNUAL REPORT OF THE TREASURER.

Receipts.

Balance March 7, 1914	$182.58
Dues	357.00
School Science and Mathematics	70.50
National Geographic Magazine	4.00
Scientific American and Supplement	39.30
Popular Mechanics Magazine	10.00
Popular Electricity Magazine	2.75
Annual Dinner	67.50
	$733.63

Expenses.

Reports, Notices, Postage, etc.	$206.86
Secretary	50.00
Expenses of Meetings	62.79
Scientific American and Supplement	39.30
National Geographic Magazine	4.00
School Science and Mathematics	76.50
Popular Mechanics Magazine	10.00
Popular Electricity Magazine	3.00
Annual Dinner	70.50
Balance March 20, 1915.	210.68
	$733.63

Mr. George Cowen then reported for the

COMMITTEE ON NEW APPARATUS.

Apparatus was shown as follows:

A model of the compensated balance wheel of a watch, six inches in diameter, of metal, so that the expansion may be shown when a Bunsen flame is applied to it. Made by Knott.

A piece of apparatus to show that the friction in pipes varies with their length. This consists of a metal pipe of small bore, bent at each end in a semicircle so that the two openings face each other, about a foot apart. A metal T tube is inserted in the pipe one-third way from one end. Through this pipe either air or water may be forced, if air is blown through the T tube, from which it passes to the two curved ends. A wheel made up of four vanes, fastened at right angles to the plane of rotation is placed between the openings in such a position that the air from each side acts equally on the vanes, thus bringing the wheel to a standstill. The place where this occurs will be nearer the opening that is farther from the T tube.

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If water is forced through the tubes, and a tumbler is placed under each end, the tumbler under the end nearer the T tube will fill twice as fast as the other.

A porcelain base mercury contact current reverser. Put out by Knott.

The latest form of Knott's Wheatstone bridge. The slider is fixed, so that it cannot fall off. The known resistance coils are in the apparatus. The length of wire, resistance of which is to be determined, can be accurately varied by means of posts set at 10 cm. intervals between the two ends of the bridge. The galvanometer is not included with the bridge.

A large vibrating electric bell, with large knob on the clapper to retard vibration. With a mazda lamp in series with the bell, it can be used on the house circuit, and the make and break of the circuit shown by the lamp's lighting.

Mr. Cowan suggested that the vibration frequency of a tuning fork be determined by having a piece of smoked cardboard slide under the tuning fork. To do this use a wooden board to which is fastened the smoked cardboard. Tilt the apparatus so that the board will slide freely. The smoking is done with burning camphor, and the record preserved by blowing with an atomizer some artist's fixative over the surface.

Resistance coils with Edison base, to use in cut-outs can be secured from Ward-Leonard, Bronxville, N. Y.

Mr. Brayton then briefly described the

ELECTRICAL EQUIPMENT OF THE PHYSICS LABORATORY OF THE MEDFORD HIGH SCHOOL.

The Electrical Equipment consists of a switchboard with five circuits:

(1) 67-113 volts D. C. from a Wagner Rotary Converter.
(2) 110 volts A. C. from the lighting circuit.
(3) 3-20 volts D. C. from a Holtzer-Cabot one kilowatt generator direct connected to the Wagner converter which serves as a motor.
(4) 0-55 volts D. C. from a chemical rectifier capable of giving one kilowatt and connected to an auto-transformer.
(5) 25 volts A. C. from a transformer which is also connected to give a three-wire system with 25 volts between the middle and either outside wire and 50 volts between the two outside wires.

Distribution from the switchboard is made by means of five pairs of horizontal busbars, one for each of the five circuits and eleven pairs of vertical busbars connected to wires going to the various tables. Contact is made by heavy brass plugs with insulating handles, so that any one of the five circuits can be put at any table.

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The laboratory also has a Kinney Rotary Air Compressor, oil sealed, run by a 2 h. p. Wagner Induction Motor. This is tested for 100 pounds pressure, but by means of a governor can be set to hold the pressure at any desired point. By means of two three-way cocks, this pump may be used for exhaust instead of compression and has shown over 95% vacuum with a mercury gauge, that is, over 28.5 inches with a barometer reading of 30 inches.

Following is the report of the

COMMITTEE ON NEW BOOKS.
Clarence Boylston, *Chairman.*

"FIRST YEAR OF SCIENCE."

By John C. Hessler, Ph. D., Professor of Chemistry, James Millikin University, published by Benjamin H. Sanborn & Co. 484 pp., 311 cuts and figures.

The aim of the book is to present a course in general science that will embrace the most important fundamental principles which the pupils may need in their subsequent study and to lead them to observe and think more scientifically about the facts and conditions that concern their daily life.

The text proper consists of descriptive matter, of exercises and chapter summaries. About half of these chapters consist of elementary physics and chemistry. In the latter half of the text there are chapters on Water, Heat, Air and Light in the House, The Weather, Rocks and Soil, Plants and Animals.

For those who wish it, there is a laboratory manual having the special feature of suggesting experiments to be tried at home with simple apparatus.

Also a Hand Book on the Teaching of First Year Science. This is designed to assist those teachers who are in doubt as to how to handle the subject.

The book on the whole embraces a comprehensive and general science course, which, if presented in such a way as to arouse and hold the interest of the pupil, should prove to be a profitable course for first year high school work.

"FIRST YEAR SCIENCE."

By William H. Snyder, Sc. D., Principal of the Hollywood High School, Los Angeles, published by Allyn & Bacon, 1914. 460 pp., 296 illustrations, 26 maps, 133 experiments.

In the preface the author states that the book is meant for immature students, hence the language is simple and the principles thoroughly illustrated by experiments and pictures—that all subjects of elementary school science, physics, chemistry, meteorology, botany, zoölogy, physiology, astronomy, physiography, forestry and agriculture are treated so that a pupil may find out which ones he wishes to study later.

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There are fifteen chapters, including the appendix which consists of five pages, treating these subjects: determination of latitude, topographical maps, contour maps, projections, cylindrical projections, stereographic projections and an experiment in contour maps. Each chapter is followed by questions which emphasize the principal parts.

Chapter I is on the earth and its neighbors, including the subjects, planets, meteors, comets, but does not explain what they are, properties of matter, inertia, Newton's first law, gravity, weight, etc., relation of earth, sun and moon. Chapter II is a repetition of geography on latitude, longitude, time, etc. Chapter III, 23 pages, 18 experiments, is on energy, heat, light, sound. Chapter IV, 41 pages. The Earth Crust, is on the subjects: physiography, meteorology and agriculture. Chapter V, 70 pages, The Atmosphere of the Earth. In the section where lightning is spoken of, the following work in electricity is taken up; conduction experiments in electrical communications, cells, telegraph instruments, and the wireless. Chapter VI, 60 pages, The Live Part of the Earth, covers a wide range of subjects in botany and zoölogy. Chapter VII, 38 pages, Life of the Earth as Related to Physical Conditions. Chapter VIII, 20 pages, The Sea. Chapter IX, 20 pages, Coast Line. Chapter X, 50 pages, Water Sculpture. Chapter XI, Ice and Wind Sculpture. Chapter XII, Low Areas of the Earth. Chapter XIII, High Areas of the Earth. Chapter XIV, Volcanoes. These last chapters deal with the subject found in any geology or physiography, but take into account their relation to life.

This book is particularly a treatise on physiography, treated in rather a unique way. Only a part of a chapter is devoted to any one of the other elementary sciences, except physics, and only a page or two to chemistry. A teacher using it would have to be well versed in all the elementary sciences and would need many books for references in spite of the fact that the author claims that the book is complete and needs no reference books.

Following is the report of the

COMMITTEE ON CURRENT EVENTS IN PHYSICS.
Emerson Rice, *Chairman.*

A voltmeter recording tensions as high as 300,000 volts has been perfected.

An antennaeless wireless outfit has been devised for train service with radius of 300 miles.

In place of the antenna is a sealed hollow copper sphere, 6 inches in diameter, placed on a brass cylinder a foot high and 3 inches in diameter. This is placed on the roof of the car. The sphere contains a vacuum, and inside of the sphere are coils of copper wire.

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Besides the wire attached to the sphere there is a hollow iron cylinder, about 4 inches long and a half inch in diameter. This rod reaches from the sphere into an inductive coil—that is, a coil of copper wire wound carefully about a spool, in tne hollow cylinder of which is the rod. The copper wire, about 3-32d of an inch thick, is about 700 feet long and leads also to the receiving instruments. The third part of the invention is the brass cylinder in which rests the copper ball. The cylinder is a foot high and 3 inches in diameter.

Direct transcontinental telephonic communication, made possible by the Pupin coil, has been successfully accomplished and the first conversation was carried on between A. Graham Bell and Mr. Watson, whose names are associated with the invention and development of the telephone.

The commercial development, however, of this transcontinental service involves enormous expense, and the solution of the problem seems to lie in the development of wireless telephony.

High-speed telegraphy has reached a very successful state in England. Baudot quadruple duplex sets have been established between London and Birmingham by means of which over 2,000 messages have been transmitted in twenty-four hours.

The speed of wireless transmission has also been greatly improved in the same country. A test recently made by the Marconi Company between Chelmsford and a point in Ireland, showed 140 words a minute.

In the Boston *Transcript* of March 13, 1915, is found a very interesting description of an "electrical weather prophet" in successful operation on the roof of the Edison Building in New York City. Its object is to detect storms, notifying the Electric Lighting Station in time to allow proper preparation for the increased demand for light throughout the city which has often boosted the normal day load from 60,000 kilowatts to 105,000 kilowatts within a half hour.

Detection is brought about by what is practically a wireless telegraph with receiving circuit. The apparatus consists of an aerial frame, a spark gap, a coherer and condenser, a ground connection, a combined bell and decoherer with a relay, two batteries and a short-circuiting switch.

The storm a few hours distant, causes the bell to tap every 15 to 5 minutes. If nearer, two hours away, the storm records itself by minute or half-minute taps. For a full hour before the storm breaks the bell rings continually, then stops abruptly, as the apparatus is short circuited on the breaking of the storm.

Long before this, however, every thing at the generating station is in readiness, boilers fired up, and turbines throbbing.

Its principle rests upon the fact that summer storms are usually associated with electrical disturbances. To some extent the apparatus is effective during winter weather, though storms at that season show comparatively weak electrical manifestations.

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Following is the report of the

COMMITTEE ON MAGAZINE LITERATURE.

Scientific American. April 4, 1914. "Gravitation and the End of the World." "The Water Drop as a Microscope."

April 11. "A Great Telescope for Canada."

April 25. "Lake Washington Canal Locks."

May 2. "Ultra Violet Radiation."

May 16. "Analyzing the Human Singing Voice." "Evolution of the High Tension Insulator."

June 20. "Forty-Five Years of Air Brake Evolution."

June 27. "Repair of the Los Angeles Aqueduct Siphon" (a striking example of hydraulic pressure).

July 4. "An Under Water Siren to Prevent Collisions at Sea." (Professor Fessenden's Oscillator).

August 1. "The Elephant Butte Dam." (Irrigation in Southern New Mexico.)

August 15. "Sterilizing Water with Ultra Violet Rays."

August 22. "The Indomitable Engineer." (Concrete Bridge in a Caisson, East River, N. Y.)

August 29 . "A Permanent Electric Current without Electro-Motive Force." (Professor Onnes.)

September 5. "War Number." This and later numbers contain a fund of data. The *Scientific American* believes in increased armament.

October 17. "The Electric High School." (Rupert, Idaho, building run entirely by electricity, including heat.)

October 24. "The Lowest Organ Note. 128-Foot Pipe." (CCCCCC = 4 vibrations per second.)

December 26. "Infra Red Rays in Telephotography." "Righting a Twenty Thousand Ton Grain Elevator."

January 9, 1915. "Archimedes and His Lever."

January 16. "Electric Cooking."

January 23. "Floating a Stranded Ship on Air."

January 30. "Compressed Air Break Water."

Scientific American Supplement. April 25, 1914. "Chemical Affinity Interpreted as an Electric Phenomenon."

May 2. "Temperature Variation in the Steam Plant." "Properties of Water at High Pressures and Low Temperatures." (Five kinds of ice, Harvard.)

May 9. "Recent Discoveries in Physical Science."

May 16. "Recent Discoveries in Physical Science."

June 20. "How Bodies Fall in Deep Vertical Shafts."

June 27. "Calculating the Heat Loss from Buildings." "Compression Tests on Wood."

July 18. "On the Quantum Theory of Light."

August 29. "Investigations at the Cryogenic Laboratory at Leyden."

September 12. "Thread Recording Micro-Barometer."

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October 10. "Heat. A Lecture for Beginners."
November 7. "Air-Break Switches."
November 21. "New Experiments with Liquid Air."
December 19. "Artificial Daylight."
December 26. "Neon Light Tubes."
January 2, 1915. "Purification of Water by Ultra-Violet Rays."
January 9. "Suction Between Ships."
January 16. "Apparatus for Demonstrating Newton's Laws."
January 23. "Applied Electric Science in 1914."

World's Work. The issues for February, March, April, May, June, July and August contain a few pages, each describing certain devices, more or less interesting and ingenious, under the title "Man and His Machines." Later numbers have nothing. The publication has degenerated into a war manual.

Technical World. The usual Bunk.

Electrical World. April 19, 1914. p. 768. "Nitrogen Filled Lamps at Filene's Store." Good. Illustrated.

May 23. p. 1145. "Illumination of Lord and Taylor's store in New York." Illustrated. Good. p. 1151. "'Electric' High School of Rupert, Idaho."

July 4. p. 21. "Illumination Features of the Panama Canal." Illustrated. Good.

December 5. p. 1100. "Comparison of English, German, and American Wiring Rules." Rather long but very good.

December 26. p. 1241. Electric Equipment of the Panama-Pacific Exposition." Good. Illustrated.

January 2, 1915. pp. 3-28. "Review of Electrical Industries by Departments." Rather technical but good.

January 9. "Illumination of the Woolworth Building." Brief. One illustration, p. 132.

January 16. p. 158. "Effect of the Third Harmonic in Voltage Wave." A very mathematical article; one of a series useful to show the need of mathematics for the engineer.

January 23. p. 240. "Interior Construction; Some Points to be Observed in House Wiring." Brief.

January 30. p. 288. "Electric Towage System for Panama." Illustrated. Good. p. 279. "Inauguration of Transcontinental Telephony." Good.

February 13. p. 391. "Illumination of the Panama-Pacific Exposition." Illustrated. Good.

Electric Journal. Usually very definitely technical, though not mathematical. Useful only for the teacher and then only occasionally.

April, 1914. p. 187. "George Westinghouse." Good appreciation.

May. p. 240. "Operation of the Single Phase Equipment of the New York, Westchester and Boston Railroad Fair." Some illustrations.

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June. p. 307. "Large Incandescent Light Units."

September. p. 468. "D. C. Motor and Generator Diagrams." Many illustrations, but small in size, of the connections. Good.

January, 1915. p. 1. "Electrical Progress in 1914." Good but rather technical. p. 46. "Engineering Notes."
Question box good.

Harper's Magazine. April, 1914. p. 374. "What is Gravity?", by Sir Oliver Lodge. Good, thoroughly up to date, but rather technical.

October. p. 783. "The Absolute Zero," by Robert W. Wood. With diagrams. Good.

September. p. 566. "Positive Electricity," by Sir J. J. Thomson. Illustrated. Good.

Popular Science Monthly. September. p. 292. "The Paradox of the East Wind," by Alexander McAdie. "Report of Some Blue Hill Observations." Good.

December. p. 616. "Crystals and X-rays." Brief abstract of lectures by Prof. W. H. Bragg of Leeds. Good.

January, 1915. p. 103. "Progress in Photography." An outline of the subject. Brief but good.

February. p. 164. "Thought in Science and in Science Teaching," by Dr. B. C. Gruenberg. A scholarly discussion of the value—or lack of it—in the science work of the high school and college. For the teacher only.

School Science and Mathematics. April, 1914. p. 303. "Verifying the Laws of the Pendulum," p. 312. "An Experiment on the Expansion of Water." p. 338. "Graphical Representation of the Error in the Mirror Formula," all brief and good.

May. p. 404. "A New Apparatus for Experiments in Moments." pp. 411, 312. "The Loaded Table Problem." p. 415. "The Variation in Focus of Lenses."

June. p. 495. "The Teacher's Conception of Physics." A good discussion of the subject from the college professor's point of view. p. 504. "Physics Below the High School." A course outlined. p. 518. "A Pressure Equalizer for Air or Gas." p. 519. "Heating Effect."

October. pp. 555 to 572, several articles of interest: The determination of E/M for cathode rays. The order of topics is physics, a simple barometer, and hysteresis losses.

November. The whole number is so good that it is a waste of time to specify articles.

December. p. 770. "Two Courses in Physics—Elementary and Advanced.

February. p. 93. "The Mission of Science in Education." A good article. p. 149. "A Useful Electric Combustion Furnace."
In each number the "Science Questions" are useful.

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On recommendation of the Executive Committee the following were unanimously elected to membership:—

Active,—

Thomas C. Bailey, High School, Ludlow, Mass.
Ernest S. Schuman, Wentworth Institute, Boston, Mass.

Associate,—

Horace F. Bates, High School, Hanover, Mass.
Walton E. Briggs, High School, Plymouth, Mass.
Mrs. Helen B. Colson, High School, Watertown, Mass.
Ethel V. Sampson, Latin School, Cambridge, Mass.
Wilhelm Segerblom, Phillips Exeter Academy, Exeter, N. H.

The following officers were then elected for 1915:—

President, Clarence M. Hall, Springfield, Mass.
Vice-President, Frederick E. Sears, St. Paul's School.
Secretary, Alfred M. Butler, Boston, Mass.
Treasurer, Percy S. Brayton, Medford, Mass.
Executive Committee, W. H. Timbie, Wentworth Institute; C. H. Andrews, Worcester, Mass.; W. E. Richmond, Newton, Mass.

Mr. N. Henry Black then read an appreciation of

PROFESSOR ERNST GRIMSEHL.*

On October 30, 1914, Ernst Grimsehl fell in the bitter fighting near Langemarck, along the Yser line. It was only two days before that he had received the iron cross. Although he was in his fifty-fourth year, yet voluntarily and full of enthusiasm he responded to the call to the colors as an "Oberleutenant der Landwehr." With the 213th regiment he marched, on October first, across the Belgian frontier. For only a few weeks was he permitted to fight for his country which he so dearly loved. He died, as so many others at his side, without living to see the victory which he so confidently hoped for.

In his death the German educational system loses a personality which was unique in its character and therefore cannot be replaced. All his thoughts and efforts were directed to the ideal of placing physics teaching on a firmer basis and of bringing it nearer and nearer to perfection. His friend, A. Keferstein, has sketched in the *Unterrichtsblättern* the character of his work with beauty and conviction. He says: "His preëminent manual dexterity and his thorough knowledge of the instrument maker's art, which he as a student had gained in his vacation days from the masters of the art, qualified him for the creation of clean-cut models of apparatus which he continuously tried out at every point, correcting their first faults with his masterly hand till they responded to his every wish." Of his original, inventive skill as an experimenter, numerous publica-

* A translation of Poske's article in the "Zeitschrift für den Physikalischen und Chemischen Unterricht," January, 1915.

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tions bear witness; but one must have watched him getting ready for an experimental lecture, such as he was wont to give almost every year at the spring meeting of the Association for the Promotion of the Teaching of Mathematics and the Natural Sciences, in order to gain the secret of this skill. He was as tireless as he was enthusiastic in his efforts to perfect his arrangements, often by

PROFESSOR ERNST GRIMSEHL

hours of work in a strange place and in a strange laboratory, so that he might manage things there just as in his own rooms; everything was carefully tested before he began his lecture. Thus it came about that his demonstrations became the star performances and attractions of each of these meetings.

It is difficult to enumerate all the pieces of apparatus for purposes of instruction and investigation, which we owe to him. These are almost all published in our magazine, in which he took a lasting interest. Even the first volume, in 1888, contained a report of his

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paper in which he published a new method of measuring the intensity of a tone. In the second volume there appeared the first original investigation from his hand, in which he described two pieces of apparatus for detecting the nodal points and internodes in a sounding column of air. The last lecture, which he gave in the spring of 1914, upon a new and simple means of showing the interference of light, he had also intended for our magazine. However, before he came to write it down, the war had pressed in his hand the sword instead of the pen.

Of his books only two may be mentioned here: the large "Lehrbuch der physik," which has in five years gone through three editions, and the "Didaktik und Methodik der Physik" (a part of Baumeister's Handbook), which, in spite of its brevity and its strong personal color, is rich in valuable advice and fruitful ideas.

Death has brought his work to an untimely end, but the influence of his creative work will live after him and assure for him a grateful memory among his followers as well as in the history of the teaching of physics.

May I add a few words to give you my own impression of Professor Grimsehl.

First, he had a real genius for the invention of physical apparatus. Clever with his hands and in the use of tools, he delighted to work in his shop, to make some bit of apparatus which should elucidate some hard point in physics so clearly that it would seem easy. His endless patience and tremendous energy were a constant inspiration to me. If there were time I would like to enumerate some of these clever bits of apparatus which impressed me, or, better still, show them to you in operation.

Second, he was a matchless class-room and laboratory teacher. He had carefully organized his laboratory equipment so as to save his own time and energy. Although he was exceedingly dextrous in performing experiments before the class, yet he was one of the first of German teachers to see the value of having the students do experiments with their own hands. His classes worked with very simple apparatus in even front. In the class-room he was energetic, but never nervous.

Third, as the principal or director of a large boys' school, he insisted on having clerical assistance and the modern office appliances, such as a typewriter and telephone (things rarely found in a German headmaster's office). He devoted one definite hour each day to parents and other visitors, in order that he might have time to teach and study physics. He gave his fellow-teachers much liberty in their work. In some way he got a very wholesome spirit among his boys, which helped much toward clean thinking. His annual reports as director showed that he took a real interest in the whole boy, his outside activities, his books, and his sports.

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Finally, as a companion I found him most delightful. Always approachable, unselfish and dependable. He had a very sunny disposition. Personally, I shall always count it a rare privilege to have known even for a week, Ernst Grimsehl.

Mr. Black then presented the following:—

Whereas, The Eastern Association of Physics Teachers has recently learned of the untimely death of one of its most highly esteemed foreign correspondents, Professor Ernst Grimsehl, the Director of the Oberrealschule auf der Uhlenhorst, in Hamburg, be it therefore

Resolved, First, that we express our deep appreciation of Professor Grimsehl, as a rarely gifted inventor of physical apparatus, as an inspiring and sympathetic teacher of boys and fellow-teachers, as an accomplished and efficient school director, and as an indefatigable and illuminating author.

Second, That we hereby express our profound sympathy with his family in the sad and irreparable loss which they have sustained.

Third, That these resolutions be entered on the minutes of this Association, that a copy be sent to his family, and that a copy for publication be sent to *School Science and Mathematics* and to the *Zeitschrift für den Physikalischen und Chemischen Unterricht.*

These resolutions were unanimously adopted.

Next followed the discussion of the subject of the meeting,

WHAT SHOULD BE THE AIM IN HIGH SCHOOL PHYSICS TEACHING?

Dr. Charles F. Dole, President of the Twentieth Century Club, delivered the opening address, speaking

FROM THE RELIGIOUS POINT OF VIEW.

What do we mean by religion? We all have, I think, a very beautiful and large conception of religion. It is not something that we should pay our respects to on an occasion, or on Sunday, and then leave out for the rest of the time, but it is our thought, and our feeling, and our conduct also, with respect to the wholeness of life, the wholeness of the universe. What is our highest thought of the universe, in the most spiritual terms? And what is the feeling that naturally comes from the immense thought of the universe as pervaded by spirit? And then, thirdly, in the realm of conduct, what is the sort of conduct that accords with such splendid thought and such reverent feeling? Thus the idea of religion is three-fold as to the wholeness of life. Thus at once we see what the religious point of view is. It is that of the person who sees life as a whole, who believes in the divine universe and who feels that spirit rises to its highest terms in good-will, power, beauty, and all the other great names that express the highest that man knows; who believes

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that this universe life is a life which man shares, both in its thought and in its beauty. Man feels in himself the righteousness of the universe, the truth of it, as well as the beauty and the good-will of its purpose,—a purpose which in some broad sense seems to be absolutely necessary in order to give us an adequate idea of its wholeness.

So then, when a man speaks from the religious viewpoint or teaches from the religious viewpoint, he speaks and teaches from the highest that is in him. We all know what it is to be at our best. At our best we are religious whether we know it or not, whether we make a profession of religion or not. We are righteous, we are honest, we are just, we are friendly, kindly and generous.

Now take the relation of the teacher to the pupil. Here the religious point of view means that the man, the teacher, is all there, is at his best, with all his faculties at work; he is acting or teaching from the center of his being; hence he has imagination and enthusiasm, without which no good work is possible.

Of course, what I am saying about the teaching profession is true about every profession of man. We are coming to see today that no man can be too well equipped for his task. The bookkeeper, the care-taker, cannot be too well informed, cannot know too much, and cannot be too kindly a man. He must be a man who is all there in the height of his being in order to work with devotion and success. We are accustomed to think this way specially about all the professions. We are accustomed to think that a doctor cannot be first-rate, unless he is a man filled with good-will, a man of enthusiasm for his profession and greatly devoted to it.

We are sure that this is true in the case of every efficient teacher. As teachers of science your field is filled with beautiful illustrations which can be brought to bear in the way of emphasizing the fullness of life.

What is it that you and all teachers are seeking to do? What do you want to accomplish? Not merely to teach a certain range of facts about the physical universe, but you are trying for something more. You are trying through the use of the apparatus in your laboratories and your handling of it to develop the manhood and the womanhood of your pupils. You have special means in your power which are to most pupils very much more interesting than the old classical system was. You are using this machinery and this special kind of phenomenal information in such a way as to develop men and women, for unless you do this your teaching will be in vain. I like to think of it in this slightly algebraic form. Your precise enterprise is teaching "a"—a certain amount of physics, if you please, but incidentally, if not more important than "a," you add "plus n"—plus the infinite. You cannot measure what you want to add to the "a"; you cannot measure what is always going to be learned along with "a"; that bigger thing is "n," the infinite. It is

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that which lifts one above a mere plodder to become an all-round man.

The great ideal of education in the public schools is here brought clearly to our mind. What are we teaching for? For what are we spending all this money for the splendid equipment of our schools, unless out of this teaching we develop admirable, devoted, loyal citizens? The whole system would break down if we taught them simply how to earn a living!

I like to think of the man at his best as not simply a citizen of the country, but a citizen of the universe; one who is himself a unity with an understanding of the immense relations which every human being bears to the great whole, so that wherever he might go, if he had incarnations over and over again, as many people think we are going to have, he would be able to be at home, and find his place and put himself in touch with conscious life wherever he was,—a citizen of the universe, rich, capable and strong. I believe, therefore, that every teacher of natural science ought to have an education a good deal larger than that of his own profession. It used to be said that everybody really ought to have a classical education. The classical education, I suppose, was intended for a background for life, to get a knowledge of the philosophy of life, a perspective view, so that when a man came forth from the schools with his vocational training, if you please, or with his knowledge of a profession, he was not only equipped to earn a living with his professional or vocational skill, but he was also a man of large interests and and an ample understanding of life. Thus, when a calamity comes upon the world such as we see today, the man would know enough of history, and be able to see history in such perspective as not to give up all his faith in God and man, and say that the universe was going to destruction. He would know that such things are but part of the process of bringing man up from the savage life to higher and lasting civilization.

Now look for a moment at your method. See how beautifully your method of study applies everywhere to the making of manhood. What do you do with your boy? You bid him watch and observe with attention, and then to report just what he sees, not something else. And again you compare the notes of a number of observers, and find out what each one has seen, and by comparison of all these reports you get a many sided view of the object in question. Here is one of your parables of all human life. Are you not going to use that same method when you go out among men? Are you not going to watch everywhere and find out what is true, and not to report anything except what is true? Are you not going to use, as you have to use in the laboratory, as exact language as possible to express what you have seen? You have in this method of your science one of the greatest assets of human life and relations that any one can possibly acquire.

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Take another parable, which is so obvious that I hardly need speak of it in passing. I mean the exactness that is required in your kind of study. In other studies we cannot expect such exactness and perfection. In the study of language, for instance, there is rarely a lesson worthy of the mark of 100. In language we are always a little short of perfection, perhaps because we are reaching up towards the expression of an infinite art. But you are dealing with problems of exactness, as becomes numbers, weights and measures. It is possible to have the pleasure of hitting the mark.

This same exactness goes over likewise to the teaching of life. Not that one should always be moralizing, but because through exactness of workmanship the teacher can often show the student the nature of the vital and human problems that arise from time to time in the class room. He must be the first to set the example in exact fairness, justice and truth, and at the same time must show patience and a willingness to learn, a willingness to receive information and a willingness to retract, if necessary, instead of the old idea that a teacher must "save his face" at any expense, and never take back anything that he has said!

One thing that strikes me whenever I look at a lot of delicate scientific apparatus is the judgment and care with which you have to handle these things to get your results. You cannot blunder with your tools and appliances. You must use them with the utmost gentleness. You are handling the tools and implements of your work with care that nothing shall be wasted or destroyed, and that the very best results can be reached. Are you going to be less gentle and firm in handling the human souls in your care? Are you going to blunder and lose patience, and run the risk of destroying or hurting the delicate material in your hands?

A well-known labor leader will speak to you in a little while. I am reminded of the relations in which men are bound up in human society, where we are constantly seeing the most dreadful damage done to human life and the souls of men. You ought to be able through the breadth of your sympathies to help your boys to understand, at least, the underlying laws of all human association, and to catch sight of the friendly good-will, without which no man can ever be an all-round employer or workman.

Another characteristic of your profession is the sudden surprises that take place in science. There is nothing monotonous about it. You have, for instance, the strange law by which the same substance at a certain fixed temperature changes almost instantly from a gas into a liquid, and again from a liquid into a solid body. You see water changing into ice or steam as the temperature changes. It is a suggestion of what is taking place all the time in human life. They tell us that you absolutely cannot change human nature; that we are going to have the same evil powers of greed and hate at work in the world for ever and ever, because "they

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always have been so." But anyone who knows history has no business to believe this, Anyone who knows science has no business to believe it. He knows that all kinds of sudden surprises are likely to occur. When the temperature becomes right and the proportions have been so adjusted as to bring the result, lo, you have something entirely different. We are already beginning to see the possibility of an entire change of conditions in this world with regard to war. We shall see the working people, because they bear the brunt of it, and the women, because they bear the sorrow of it, slowly climbing to take the power from the expert statesmen and diplomats who have made such a blank failure of their system. Some of these statesmen are already expressing this same idea,—that to promote the best industrial conditions it is not necessary to fight with one another, but to win the love and respect of other peoples by a change of attitude, and through a thousand delicate threads of friendly intercourse.

The world of science, the phenomenal world, is all the time leading you out into other relations. You begin with the materials out of which life is made. You know that this material first existed in a non-vital form and then, like a flash, there came into the world consciousness. There must have been a time when there was no consciousness and no life worthy of the name, and then suddenly the time was ripe and you had consciousness, and life, and then human life appeared, as if everything had led up to it.

But what is human life for? Has it no law of purpose and progress? We in America believe it has. We believe that each generation of us lives in order that the generations after us may be better and richer, that there is a line of development carrying us on to make use of us. We can enter into, acknowledge, and share in this splendid purpose. We can devote ourselves to provide a world of real civilization, where every child will have an opportunity. And what is the part of the science teacher in this scheme? Utter and self-sacrificing devotion, repeated over and over again in every teacher who catches the spirit of it. On one side he studies the material, but on the other he is a builder of the temple of life.

There is also the element of the unseen in your science. You trace your science backwards and what do you find? What is there behind all these things that we see and hear? The great scientists are teaching us what is perfectly familiar to you, that what is behind and under all is absolutely invisible. We seek to know what the electric power is, or the wonderful new unit—the electron! Shall we call it matter? It is more spiritual than it is material.

And here we touch on the very realm of religion. The scientific man goes back as far as he can and touches mystery. The great question of life is whether the mystery to which we are constantly seeking to go back, is a mystery of darkness or the mystery of light. Our religious faith says that it is a mystery of light and life, and

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that we are akin to it, the children of its Power and Beauty. If this were not so, there would be little reason for special enthusiasm in a study that only led to denser darkness. But we see great laws everywhere working. Marvelous rules of truth, justice and good-will challenge and support us in whatever we do.

It seems to me that you teachers have a splendid opportunity. You have the greatest of enterprises given into your hands. You are dealing with the most precious material that there is in the universe—the human soul and the human mind. You cannot reverence it too much. You do well to admire the marvelous things that science discovers; you cannot admire enough the qualities and the possibilities that are in the boys and girls who are placed in your hands. They are placed in your hands, as I have tried to show you, from a religious point of view, that is, from the highest human point of view. This appeals to everything that is in you; you cannot be too large-hearted, too broad-minded, too sympathetic. We recall our own best teachers; they always had more than learning; they were also generous, sympathetic, and even-tempered with us. And all through the broad land there will be men and women who will be saying of you bye and bye what some of us are saying about the teachers who trained us,—what an impression you made on their minds and their lives; that they owe more to your influence than to anything else that they can remember!

Is it not splendid that this kind of faith may come to every teacher,—to catch the vision of the possibilities of his life to help on the great enterprise of human civilization, the noblest enterprise that man can undertake!

Mr. Henry Abrahams, Secretary of the Central Labor Union of Boston, then spoke

FROM THE POINT OF VIEW OF THE LABORING MAN.

You will not expect anything of an academic nature from me. My *alma mater* has been the trade union and the workshop. It may not be in good form for one from the workshop to criticize our present system of instruction in the city of Boston and the state of Massachusetts. But in speaking to my fellow workmen I have never flattered them. I did not always agree with them, and I may not agree with you.

I have read somewhere that when Harvard was founded it was for the purpose of educating men for the ministry. We, of course, have got a little beyond that today. I want to say amen to all that Dr. Dole said in regard to religious training, because without religion there would be no morality. Without that we would have no discipline.

When we first founded our school system we found that there was considerable opposition in this good old Commonwealth to our free schools, more especially to our high schools. Let me say in passing

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that I believe that every member of a school committee, and every teacher in the public schools should be a public high school graduate.

You know and I know that there is but a small percentage of grammar school graduates who go to the high school, and that there is a still smaller percentage of high school children who graduate. Judging by the results, something must be wrong with the system. There is not any question about that. Let us face that situation frankly and openly. There is nothing to keep the high school boy at school. There is nothing there that he is taught that fits him for his occupation later in life. We do not all want to be professional men. We are not all adapted either for the law or medicine. We are not all going to be architects or civil engineers. Something that would be of use to us later in life ought to be taught in the public schools. We ought to take a tip from Germany. Germany, as far as practical education is concerned, is far ahead of the United States. We have much to learn, and we made a step forward when we took up vocational training and industrial education. Perhaps the Franklin Institute and the Wentworth Institute are doing more for the future generations than even our public schools.

You teach too much, too many things. What is the use of compelling a child to take up botany? Can you tell me? It isn't going to be of much use to the girl in the factory. The use of needles would be of much more benefit to her, especially if she knew how to make her own dresses. By the way, how many American girls can do that? This might be of some use to her in life even if she didn't work in a factory but when she becomes a wife.

I believe civics ought to be taught in our schools and I believe that the boy ought to understand what a republic means and the duties of citizenship. How many of our boys in the public schools know anything about this subject? About one in a hundred knows anything about it, but you teach a great many things that are not going to be of any help to the boy in supporting himself or the family.

It has been said that boys and girls leave the high school on account of the poverty of their parents. This is only partially true. They leave high school, a majority of them, because they do not see any value in it to them in after life. Our schools seem to be laid out on the plan that all the pupils are finally going to college. But they don't all go. You know that. This is a great mistake. If you patterned your grammar schools and your high schools with the idea that that is as far as the boy is going or the girl is going, and you taught them something that would help them to earn a little money, you would find that a greater number would be graduated from your high schools and a greater number would remain in the grammar school after they were fourteen years of age.

Working people discuss these things in their homes. They ask, themselves, "Is my boy or girl learning to do anything that will be of benefit to us all later on?" In early days they taught the three

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R's, but they taught them well. Now, as far as mathematics is concerned, I don't think the high schools deserve any gold medals. There is a great deal to learn along that line. How many good readers have you got in your school? Not very many. I know some years ago an editor of a Newton paper offered a prize for any high school student that could write a business letter. I don't think it cost him anything either. Now these are things that ought not to be. There is a purpose in educating children. To have a child who can merely answer certain questions, and then to say that that is a bright boy or a bright girl is not educating the child.

Another thing. How much attention is paid to the different qualities of the children. One boy is bright; another boy is not quite so bright; another boy is dull. Now some attention should be paid to these different qualities in the children. Something should be done to develop them. I was reading the other day that a pigeon flew into a schoolroom. Now most teachers would tell the boys to be quiet and not take any notice of the pigeon and to remain in their seats. But that teacher didn't do it. He caught the pigeon and told the children all about it. That teacher knew his business. That teacher had ability to interest his class. And as I have often said, teachers are born. You cannot make teachers in any normal school. You know that and I know it. I don't care how much knowledge you have if you have not the faculty of conveying it. If you don't believe you are adapted for it, quit it. One should be called to the profession of teaching just as one should be called to the ministry. Any one can read something from the Bible, but that doesn't mean anything. It does not make good teachers just to have passed normal school requirements.

We have got to rearrange our entire curriculum. I want children to be taught something that will be useful to them in after life. I want the teacher in the high school to remodel the whole thing with the idea that the boy goes to the high school, and isn't going any farther. That high school is going to fit him for his vocation in life. The teacher is going to study and ascertain what he is adapted for. It would not be any great crime if during certain hours of the day the boys were taught to use tools and how to make something. Take up their grammar and their arithmetic, because these can be used and applied to their various needs. You have not done this. You have laid out their studies as though they were all going to become professional men.

I don't want to say that no man shall take an examination for the bar who is not a graduate from the high school, as the bill recently in the legislature did, and that no man shall be a doctor who is not a graduate from a medical school approved by the registrar. Bacon said "Knowledge is power." In the Commonwealth of Massachusetts in 1915 it seems to depend a great deal on where you get it.

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I simply want to say this. From the wage-earner's standpoint, you have too many fads and too little that is practical. We want training that is going to fit the boy who is going to be a workman, who is going to go into the factory. I don't want the boy who ought to be a lawyer to be a blacksmith and I don't want the boy who ought to be a blacksmith to be a doctor. I want a man to be educated for what he is going to be in after life. I said something about history. A boy who can read can find out all he wants to know about history without the aid of a teacher. You cannot give the boy too much mathematics. He should have a knowledge of grammar and a knowledge of civics. A girl should know how to sew and to knit. A great many things can be taught to girls that would go a long way toward helping her to earn her living in life and to get better wages than she would get without that knowledge. And the school could be a help instead of a hindrance to the factory.

Thus you will have better men, better women and better citizens, better wives, better husbands and better fathers. You are not going to see tomorrow or next day the benefits of Franklin Union and Wentworth Institute, but the next generation will thank God that these institutions kept the children in school. I thank you and hope you will do something for your workers.

Lunch was then served by the Domestic Science Class of the Medford High School, and a social hour was passed.

AFTERNOON SESSION.

Continuing the subject of the meeting, Dr. Hermon C. Bumpus, President of Tufts College spoke

From the College Point of View.

Before indicating the aim in high school physics teaching, we must recognize three important facts:—

1. The high school is a public school.
2. Only a few, if any, of the students intend to go to college.
3. Physics, as a subject, has a value in the determination of the natural tendencies of the child and, therefore, has "vocational" importance.

The high school is an outgrowth of the academy, but differs from the academy in that it is a public rather than a private institution. While a privately endowed institution, responsible only to itself, may teach how and what it pleases, and may change its purpose from time to time, the public high school can have but one aim and one fixed policy; it must conduct itself in such a way as to yield the utmost measure of good to children of the community, and to this end it must discover their needs and its own needs and do its utmost to see that all of these are attended to. The needs, moreover, will vary

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from time to time and with the location of the school. The physics given in the country may be somewhat different from the physics given in the city, but wherever given, the course must be planned to meet peculiar and fundamental conditions of a neighborhood rather than to follow the view of some arbitrary theorist.

The idea that the chief aim of the high school is to fit students for college seems to be slow of correction. While the presence of a number of prospective college students may modify the teaching in any high school, we should discourage those who look upon this as an essential high school function. It is essential only in so far as there is a public demand for it; and, it might be added, it is not the duty of the school to artificially manufacture this demand. If it is an environmental need, it must be met, but if there are other needs which are obviously more patent, the several needs should be taken up in the order of their importance, and not necessarily in the order of what some individual may consider their relative commendability.

It is in the performance of the newer function of the high school, however, the function whereby the school attempts to discover the technical abilities of the child, his natural bent, his fondness for certain kinds of study and work, that physics takes an important place, and the aim of any course is faulty if it does not take into consideration this all-important vocational factor.

In our consideration of this factor, however, we need not forget that the tastes of any individual child are likely to change from year to year. We know that children up to about twelve or fourteen years of age may be more or less alike, but from about that time to eighteen, twenty, or twenty-two, their characteristics become differentiated. There are physiological reasons why this change should occur, and why it does not take place at the same age in all individuals. One person may have a very mature mind at fifteen or sixteen, and another may be very young at twenty or twenty-two. We may even retain some of our childish traits throughout life and derive a great deal of pleasure from them.

Our fundamental error is treating all members of a class as though they were alike, when we know that no two of them are alike. The football coach knows that they are not alike. He selects only the men of good physique, and among these, only those who show a natural fitness for the game. The chorister knows that they are not alike. He tries out the voices and selects for his choir on the basis of fitness. In both cases the students selected are pleased, because their excellencies are appreciated, and they tend to do even better what previously they had been doing moderately well. The same processes of selection applied to those who excel in, or at least show a fitness for, physics, means the extension of the same vocational principle; it means the calling of the student in a direction that is already attractive to him.

We have in the high school many opportunities of giving to the

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student the chance to look down imaginary vistas of life, but we must not conclude that these vistas should be shown but once, or when the student reacts favorably for a period, that he has necessarily reacted favorably for life. If the interest shown by a youth at the age of fifteen or sixteen is to indicate a permanent interest, we would be forced to conclude that because a large number of students at this age are interested in wireless telegraphy, all would retain this interest for life. Our experience with boys teaches us that many of these absorbing interests are short lived.

It is best to plan our work in the high school so that it will provide the best foundation that we can give our students on which to build their life structure, and it is the duty of the college to adapt the superstructure to this foundation.

There is often a material difference between the ideas of the individual student in June, when he leaves the high school, and in September, when he comes to the college, for the same biological and physiological processes which I have mentioned are going on during the vacation, and changes of location often produce changes in the individual.

If it is a good thing for the high school student to have a chance at various vistas of life, it seems to me that we should admit there is reason in arranging the courses of the freshman with the same object in mind. The more so, since the chances of his retaining his tastes at twenty or twenty-one are much greater than those manifested at the age of fifteen or sixteen.

The diagram is one that I have prepared for the faculty of Tufts College, and has not been adopted, as yet, by any one. It applies, however, to the topic under discussion.

The diagram recognizes that the colleges require certain subjects for admission. They ask that the student will either pass examinations on certain basic subjects, or that he will come with a rating certified by his high school teacher. Some of us have an idea that the subjects put in the diagram as a part of the foundation (such as are indicated by large letters) are *sufficient*, so far as basic subjects are concerned. Of these, there are two units of Foreign Languages and three in English in the lower tier, and above these are, History (1 unit), Geometry (1 unit), Algebra (1½ units), and Science (1 unit).

It is understood that the science shall be a good science, and by this I mean that it shall be physics or chemistry or biology, or, some well-planned combination of these three that requires good hard work on the part of the student. It is taken for granted that in reducing the number of required subjects to the number here shown we should expect good scholarship on the part of the student.

With these understandings and explanations, the diagram indicates a total of nine and one-half units specifically required, and, by certain blanks and shaded areas, it provides for certain electives.

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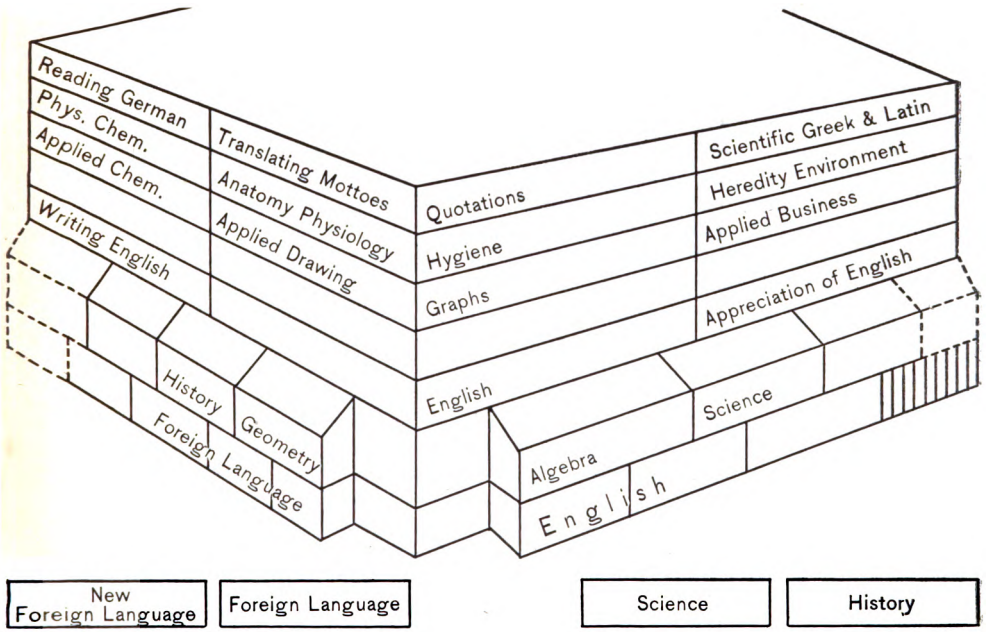
It has already been said that there should be some freedom given to the student in selecting his studies while in the high school, and I think the college might meet this condition of greater liberality by allowing three elective units as follows:—By offering, in addition to the above two units of Foreign Language, a third unit of Foreign Language, and he may offer two more units of Science, or two units of History or Economics, or he may choose to submit additional Mathematics.



This Commonwealth has a Board of Education, and it is natural to suppose that this Board is acquainted with the general educational problems of the State. It has made an examination, and it is said that there is a real need for broader courses in the high school, and it claims that this broadening cannot take place because of the restrictive agency of the college requirements. The Board argues that if the student should take the equivalent of two or three units in practical subjects which are not included in the schedule here shown, the student would be, nevertheless, well prepared to go on with college work, and, moreover, were this permitted, an opportunity would be given for many students to increase their general efficiency.

The subjects that the Board suggests cover a large range, but the essential point is that the Board is of the opinion that the statement

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of the teacher as to the proficiency of the student is sufficient, so far as it applies to a small number of entrance units.

It seems to me that it is our duty to give this proposition serious attention before rejecting it; for, if we continue to require nine and one-half units of prescribed subjects, and three units of prescribed electives, we are taking no serious risk in accepting the teacher's statement in regard to the ability of the student, on, say, two and one-half units. The college does not give up its control over the character and capacity of the freshman that enters college, for the freshman cannot continue in college without doing college work. The plan really puts more of the burden of the test on the college. The first year will give ample opportunity to ascertain the quantity and the quality of the intellectual material that has entered into the composition of the freshman class, and the college can begin its function of encouragement or of elimination as early in the college year as it may elect.

This plan, moreover, allows for a reasonable amount of freedom in the high school, and allows the adaptation of courses to general environmental conditions. If we take it for granted that the plan is practicable, we can leave the foundation shown in the diagram with its nine and one-half units of required subjects, three of limited electives, and two and one-half of free electives, and spend a few moments in contemplation of possible superstructures.

A suggestion for the lower courses in the "collegiate superstructure" is shown in the diagram, which carries through the freshman year the general subjects of English, History, Economics, Mathematics, Science and Foreign Language. It is true that this is somewhat different from the course of study at present given during the introductory year, and the year, moreover, instead of being divided into two semesters, is divided into three terms, which gives relatively shorter units.

There are distinct advantages attached to the adoption of a shorter "term unit." Among these is the fact that the short term provides for a larger number of subjects during the year and also reduces the time likely to be lost by the student, who is taking a subject for which he is not naturally fitted. The school year being divided into three terms, and each term having five subjects, offers some fifteen chances from which the student may select subjects sympathetic with his vocational bent, and, as already said, the plan also provides for an early disentanglement from unprofitable alliances.

I have been told that seven men out of ten admit that their business is uncongenial and foreign to their natural tastes. This means that the larger number of men are pursuing an artificial career, in which they take no vital interest, and for which they feel that they are not naturally fitted. I think we have all met people who have expressed themselves rather emphatically in this way, and

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when we notice how many youths take the first position that is open to them, without regard to their fitness therefor, we are not surprised at the general feeling of discontent.

A wider selection in the freshman year would bring the freshman in contact with a larger number of professors. He would not only be presented to a wider range of subjects, he would be presented to a wider range of men, and every teacher of experience knows the importance of the personal factor. An indolent student is often inspired to diligence through the presence of the right kind of a teacher, and the indifferent student may be kindled to enthusiasm through a vitalizing personality. The plan is not only good for the student, it is also good for the professor, because it gives the professor the privilege of selecting the men that he desires to enter his chosen field of study.

This plan, of wider elective in the freshman year, leads naturally to greater concentration in chosen lines during the subsequent three years of college work, and I believe it is safe to predict that a professor will carry a class composed of students naturally fitted for their work farther in three years than he can carry a mixed class in four.

I realize that I have extended the topic given me from the high school over into the college, but in doing so I hope that I have made it clear that the general aim is the same in both cases. The purpose is to provide a course that is adapted to the needs of the student *as a citizen in the process of development*, and with the intent of arousing in him a sympathetic interest that may determine the kind of work in which he will take a pleasure throughout his life.

Dean Gardiner Anthony of Tufts then substituted for Professor Dugald Jackson, who was unavoidably prevented from being present, speaking

FROM THE ENGINEER'S POINT OF VIEW.

I am not going to presume to tell you teachers of physics what sort of a course you should give in preparation for the life career of an engineer or for the engineering school, nor am I going to refer even to the subject matter. I feel that it would be presumptuous for two reasons, the first of which is purely personal. I was brought up on natural philosophy many years ago, and as I look back on the course it appears to have been quite free from nature and somewhat devoid of philosophy. I have been trying to make amends since then and some of the members of our faculty know how poorly this has been done. Secondly: for a long time I have believed that it is not the business of the high schools to fit for the college, as they have a wider field to work for; but I do believe that it is the business of the college to make very much more use of the work that is being done in the high schools. I do not know what all the colleges are doing in this matter, but realizing my own failure to utilize fully

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the studies being taught in the high school, I am now striving to reconstruct our courses so as to build more efficiently on the high school foundation. It may not be possible always to build in a scientific manner, but we can certainly utilize much more of the preparatory work in developing the subjects which are continued in college.

There are, however, some things of which I can speak concerning the work of physics teachers. There is one thing that the engineer wants, and that the college instructor wants, on the part of the students who come from the physics department, namely, a thorough knowledge of the fundamental laws of physics and mechanics, and those laws I think we have already come to believe are best established through laboratory work rather than by the old method of text book instruction and memorized formulas. Such laboratories as I find in this building, worked as they should properly be worked, will enable the student to obtain by investigation a knowledge of these laws which will drive them home as no text book education ever can. I think I may say that text books have done much to divert the education from its proper course, and in this they have been helped by our requirements for entrance to college, because the text book course is the easiest way to fulfil the college requirements. The laboratory is the part of the college and the part of the high school that appeals most directly to me because it seems to have in it the greatest opportunity for giving the best sort of instruction. In the technical and the engineering schools the thing that we feel the need of more and more is the power of keen observation on the part of the student. I think this has become impressed upon my mind during the last five years more than ever; and where can you develop that better than in your laboratory? Perhaps the biological laboratory has some peculiar advantages, but the physics laboratory can do as much. I believe that they should be worked to the fullest extent, as through them we must obtain the training in observation that will most help us in the college and in the engineering field.

There is another point about which I am always preaching and which I think is appreciated very much more in the field of engineering than in the college, and that is the training in imagination. No engineer can be successful without imagination,—I might say, a natural imagination, but it seems necessary that we should do a great deal toward training it, or else remove the barriers which we may have set up to prevent the natural development of it. The engineer knows well enough that the building of a bridge, the building of a great structure, or the success of any of our great engineering works is largely dependent upon imagination.

Another point which applies to the work of the teacher in particular is that of inspiration. For this, of course, the class room will serve as well as the laboratory except in one particular, and that is the closer contact with his students which the instructor gets in the laboratory. If he is the right sort of a man, he can inspire students

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in various ways by that personal contact, and I regard it as one of the most effective means for the education of men and women. In this connection I think we should make more use of biographies. I believe that in the department of physics the students should not only become familiar with the names of the great men and women who have helped to develop physical science, but they should know something of the life history of these people, something of the inspiration that has served to make them great.

Now perhaps you may justly criticize what I am saying as not leading toward the question of the real object, the study of physics as related to engineering. I think I could answer that better by telling you something about a work that is going on, and I refer to a committee which Dr. Dugald C. Jackson, whose place I am filling today, was the means of establishing, and which has just begun its real work. The Society for the Promotion of Engineering Education appointed a Joint Committee consisting of representatives from the leading national engineering societies to make a study of technical education. It instructed the committee to "examine into all branches of engineering education, including engineering research, graduate professional courses, undergraduate engineering instruction, and the proper relations of engineering schools to the secondary industrial schools or foremen's schools and to formulate a report or reports upon the appropriate scope of engineering education and the degree of coöperation and unity that may be advantageously arranged between the various engineering schools."

This committee has been at work now for about one year. It consists of two members from each of the national engineering societies and includes men who have had much practical experience. After they were organized and had selected a man to collect the data from the various sources and study the problem, they were advised to give this investigator such instruction as would enable him better to carry on his work. Dr. Mann of Chicago University, and a physicist, was the one chosen to conduct the investigation, and at the close of a session in which the plan of the work had been discussed, Dr. Mann asked this very pertinent question: "Gentlemen, you have given me many points, many valuable suggestions concerning the carrying on of this work, but you have omitted to make clear one point, namely, what are the objects of technical education?" There was a pause of some considerable length. One gentleman thought that he might answer that very clearly if he had a little time. Another gentleman tried to make some remarks on the question and finally paused. Smiles began to run around the committee, until finally Frederick Taylor, of efficiency fame, said, "Dr. Mann, it is up to you to find out." Now it may seem strange to you, as it did to us, that this question could not be answered immediately, but we have received some light on the subject since then. I met Dr. Mann some time afterward, and when I asked him how he was getting along with

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his report, he told me that one of the suggestions that had been given to him was to go to the employers of large numbers of students and find out what they desired and what their experience had been. He said to me: "I have done so and I have learned two things. When I asked them to define that which was of most importance, they answered, 'First, personal character, and second, education,' not defining any particular form of education, just education. I then questioned them," he said, "as to the relative value of these, and the answer was for the first—character—75%, and for the second, 25%." He then turned to me and said, "What are you doing for the 75%?"

Now, ladies and gentlemen, isn't it true that you as physics teachers are in precisely the same situation, for it is not alone physics that you are teaching; you are developing character. That is your job.

President Williston of Wentworth Institute then summed up the addresses of the other speakers.

SUMMARY OF DISCUSSION.

Mr. President, Ladies and Gentlemen:—

Your Committee has assigned to me the rather formidable task of summarizing a very large topic which has been discussed both this morning and this afternoon from four very different viewpoints.

At the outset I wish to simplify what I have to say so far as possible by frankly recognizing the fact that there are very great differences in the way in which physics is at present being taught in secondary schools. In some places a great deal of new life, interest and enthusiasm have been brought into the work by new methods, new material and new ways of teaching familiar topics; but it is also true that in other places very little of this kind of progress has been made. Please understand that I do fully recognize and appreciate that there is this wide variation in the kind and quality of secondary school science teaching. You will pardon me, therefore, if in order to economize time in what I am going to say this afternoon I appear to overlook temporarily the high spots where teaching of unusual excellence is being done, and in a similar way overlook work that is particularly poor in order that we may focus our attention upon what we may regard as perhaps the typical or average type of secondary school science teaching as we see it and know it in the high schools of the United States at the present time.

By way of furnishing background for our discussion, I would like to call your attention to two or three facts. During the last two or three decades science and science teaching has almost revolutionized American colleges and universities. It has changed the curriculum so radically that an old college catalogue of thirty or forty years ago

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would hardly be recognized today. It has not only changed the curriculum but it has changed, I believe, in an equal degree, the methods of teaching and the ways of approaching college and university subjects of all kinds. Today practically every subject in the curriculum is usually taught by what is known as the scientific method; and a very large part of the new life that has come into higher education and given it such surprising vitality in recent years may, I think, be fairly attributed, directly or indirectly, to the good work that science has done.

Now if we look into the field of elementary education—I mean the field of the kindergarten, the primary school and the grammar school—we find the same thing in almost equal degree. Elementary science and the scientific spirit, from the beginning of kindergarten teaching up through the whole course of elementary education in all places where the new thought and the new practice of education has been thoroughly applied, has marvelously changed the school that you and I knew in former days.

I do not think that I am overstating the case in either particular. The facts speak for themselves. They are true beyond question. Now when we come to examine science teaching in the secondary school, what is the situation? Has science been able to do for secondary education the same things that it has done in the fields of education both above and below? I think that those of us who are open-minded and who look at conditions fairly must admit that it has not. In fact, we are forced to admit that it has almost entirely failed to vitalize the high school in anything like the way that it has vitalized school work for children or advanced study in the university.

Is this the fault of science? Personally, I do not believe it. Is it the fault of boys and girls between the ages of 12 or 14 and the age of perhaps 18—the time usually occupied by the high school course? Again, I do not believe it. As I know boys and girls at that period of life, and as I recall my own boyhood at that period, I am convinced that there is no period of human life that abounds in equal fullness of life and vitality or that has such intensity of interest. It is not because boys and girls are not interested in things; it is not because boys and girls are not anxious to make efforts and glad to strive for accomplishment in what appeals to them as being worth while. As I go back and think of the way that I spent my time during those years, I recall that the days were not long enough. I had to get up very early in the morning in order to get in all of the things that seemed of interest to me. I was eager to begin before breakfast and to continue until long after dark, and even then I did not succeed in doing half of the things that I wanted to do. There was always something of intense interest: In summer fishing, boating, canoeing and swimming; games to play—football, baseball, cricket, lacrosse and tennis; matches to arrange and tournaments to

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plan; walking trips and bicycle trips; hunting and birds'-egging and butterfly collections to attend to. In the fall and winter there was a list of sports that was just as long, and when spring came around again we knew every spot where every wildflower grew within a radius of a dozen miles. Besides, there were chores to do, and in most instances whatever money was needed for the various kinds of sports had to be earned in some practical way.

It seems to me that this kind of universal interest in everything that has life is thoroughly typical of boys. First and last I have come in contact with a great many, and almost all of them are built upon this plan. But this is not the boy as we see him inside the high school. The life and potential energy, however, are there.

In what I have just said I have referred only to boys, but the same remarks apply also to girls. I think that they are just as eager, earnest and alert for the things that appeal to them as being worth while as are the boys; and also they are, perhaps, somewhat more conscientious than their brothers. But in spite of that fact, I have never been able to make myself believe that even girls have a great deal of vital enthusiasm for their high school instruction. There is a radical fault somewhere and, as I have said, the fault does not lie with science nor does it lie with boys and girls of high school age.

Now it seems to me that all of the four speakers today have said this same thing to you in one way or another. They have all agreed, I think, on these general facts. If they are true, it is a serious indictment and there ought to be some explanation of it. In what is left of the twenty minutes that have been given me in which to sum up this very large subject, I wish to see if we cannot get at at least one or two of the fundamental causes of this difficulty.

To start with, I think that the boys and girls at the period of their life which we are considering have two very marked characteristics. It is the *idealistic* period of life. There is no period when one can appeal so easily or so strongly to the ideals of boys and girls as at this time. In another sense it is equally true that they are very *practical-minded* at this time of life. Things that appear to them as having no really useful purpose do not command their respect. Through these two characteristics—which are not in the slightest degree inconsistent with one another—we find easy avenues of approach. But there is another faculty that is not yet developed in their lives. They have not the intellectual quality of critical judgment that comes to older people. I hope that I have made this distinction plain, because I think that it is important.

Now the first and most fundamental difficulty, as I see it, is that high school science, and especially high school physics, as it is usually taught, is attempting to make the appeal almost exclusively to these intellectual faculties which we ought to know that high school children have not yet developed. On the other hand, relatively little or no appeal is made either to the imagination, and the

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idealistic side of their natures or to their everyday practical common sense. It is very easy to explain why, in the evolution of science teaching this state of affairs has been brought about. Science was first developed in the college and the university, and almost all of the more thorough and pretentious science text books have been university manuals planned for adult minds. In order to teach the first beginnings of science to very little children, of course it has been recognized that the wonderful things of nature must be cast in entirely new form and written in language that they could understand, but for high school children this has not been done.

We are not going to get far in developing secondary school science until we take our physics and our whole natural science and translate it into a fascinating story, written in a new language that carries with it some of the idealism that Dr. Dole this morning so earnestly urged you to introduce into your teaching. That, ladies and gentlemen, it seems to me, is the first and all-essential thing that each one of you must face. I do not know of a text book that will give you much, if any, help along these lines. You must protest in righteous indignation over the existing text books until somebody hears your cry and feels a call to attempt the larger thing. As long as you are satisfied with university science diluted until it has lost its message, the kind that is served in the average text books that available, so long will the present conditions prevail.

I do not think that I am doing serious injustice to the text book writers in saying this. I appreciate that some are far better than others, but all, so far as I know, have been dominated by the spirit of the more comprehensive books. None have been willing to start entirely fresh and write the fascinating story of modern natural science in language appropriate to make appeal to high school children. This, of course, would require omitting about 95% of the topics that are usually included, with the conviction that they may well be left for advanced study. The time thus saved might permit full justice to be done to the remaining 5% that have the largest message.

As an illustration of the damage that may be done by appealing to the purely intellectual point of view, instead of to the practical common sense of high school boys and girls, I would like to describe my own sensations as a boy at the beginning of geometry. I was reasonably fond of mathematics. I had enjoyed arithmetic and algebra, and I did not expect to find any serious difficulty with geometry; but the subject started with a lot of axioms which were either very silly or had no meaning, and with a group of definitions that did not define anything. The book next discussed parallel lines that were always equally distant and yet that crossed one another at infinity. Somehow or other these things did not appeal to my boyish imagination as having any sense at all. A little later we came to the proposition that the angles on the two sides of a per-

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pendicular to a right line were both right angles. This particular proposition was proved by the process of drawing a line that was not a right angle, and thereby proving that these two lines which made an angle with one another were one and the same line. Lastly we proved that the angle which was drawn definitely as an angle smaller than a right angle was, after all, a right angle.

And all this agony had to be endured in order to prove something "which any fool would know," *i.e.* that a perpendicular to a straight line made two right angles. I wish that I could find words to describe all the kinds of foolishness that I thought at that time this geometry teacher and this text book were guilty of. I have never changed my mind. Furthermore, I am describing not alone what I felt. I knew what the other fellows felt and I knew what they said. They all felt exactly as I did. And I have seen schoolboys since, and I think I know what they are still saying about this kind of proposition.

I also recall with equal distinctness the real pleasure and satisfaction that came to me when, quite a distance farther along in the same text book, I found that the sum of all the angles in every triangle was always equal to 180 degrees. That was something that I did not know and was really useful, but it was the first sentence in the book that had been. The effect of that one simple sentence that appealed to the mind of the small boy as being worth while was that that night after dinner I read the entire book through from cover to cover. I don't imagine that a great many boys do that particular thing, but it is entirely possible to create that kind of a sensation in any boy if you will give him something that looks to him worth while.

Now my second claim is that a very large proportion of the things that we teach in our high school science, and especially in our physics, is that they are just about as senseless from the boy and girl standpoint as the proposition about the two lines that make an angle with one another and that are still perpendicular to a right line. Newton's laws of motion as an introduction to physics do not create a real thrill in any real boy. The laws of falling bodies and their uniform acceleration do not make boys want to sit up all night to read the book through from cover to cover. We must rid ourselves of the notion that this kind of nicely arranged mathematical analysis of things which are of interest to mature persons after they get into college is of the slightest use to boys and girls as an aid to make them grow.

My time is passing and I have made a number of notes from the addresses of each of the speakers that I must refer to. Dr. Dole had a great deal that was fine to say on the relation of ideals to the building of character and on those things which give the motive for all that is fine in life. He told how intimately these ideals are related to science; and it is true, I believe, that science has the possi-

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bility—physical science perhaps more than any other science—of creating that divine philosophy of life that makes us feel the purpose of the universe. Yet I have another confession to make from my own experience. While science has furnished more than all else put together this background philosophy, in my own life I never got a ray of light in that direction from any high school instruction. That is a pathetic confession to be obliged to make but it was not, I think, my fault; for I did succeed in getting in one way or another quite a little of that spirit from other persons outside the school.

The principal reason, to my mind, why high school science teaching makes such a distressing failure of these things—I do not believe that is too strong a term—is because we attempt to do too many things and to do each in a too incomplete and fragmentary way. We permit ourselves to be influenced by the text book which gives one little paragraph a few lines long about each topic and which tries to condense the great laws of nature into a few sentences of black-face type. I do not think that you can teach the real connection between the wonderful laws of nature and the laws of life in that compass. We must learn to be willing to let our boys and girls graduate and receive their diplomas without knowing quantities of things that we now regard as important in order that other things may be made a permanent part of their lives. I think that this is the only solution of the great principle that Dr. Dole so eloquently presented to us this morning. I think it is the only way in which we can secure the open-mindedness and the appreciation of the universality of life and truth that he wanted our pupils to have.

I made a number of notes regarding Mr. Abrahams' talk and I think that each one of us is indebted to him for taking the trouble to come and tell us, whose opportunity for seeing and knowing life and conditions is quite different from his, and for telling us so frankly how persons with whom he has worked shoulder to shoulder think and feel about the things in which we are interested. There are a number of things that he said that are worthy our serious thought. He did not instruct us in the pedagogy of physics, but he told us how things looked to the pupils who are leaving the schools and to their parents; and he gave us an opportunity to know something of the sensations that our work is producing in the persons whom we are trying to help. This, it seems to me, is valuable.

One of the first things that he said is identical with what I have just said. He said, "You teach too many things." He also said "You do not take time to develop real excellence in anything." And he told you that the pupils generally who are dropping out of school do not believe that it is worth while for them to remain longer. This is something which I believe we should think about most seriously. He said still another thing that I believe is tremendously important, "Not enough attention is paid to the differences in children." Somehow or other we have got to reorganize our schools and

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take this important fact into account. I do not blame any individual teacher for things as they are organized today. The school committee, the superintendent of schools, the principal, the curriculum, the tradition that surrounds and pervades the school all tend to keep us close to the fallacy that all children are alike, that they have identical possibilities and that all of them should be trained in exactly the same way and for the same goal. A more restrictive and more absolutely senseless hypothesis could hardly be created.

I thank Mr. Abrahams for telling us that we must reconstruct our school systems so as to take these ideas into account because there are as many different kinds of boys and girls as there are different words in the dictionary. What is wise for one is not necessarily wise for another; the things that would stimulate and develop Henry will not necessarily stimulate and develop John.

The particular point that I would like to impress on you physics teachers is that you have a greater opportunity than other teachers to make variations in your instruction to suit the needs of different boys and different girls—if you cannot do this in your class rooms, you at least can do it in your laboratories. There you can discover and develop individual tastes and individual aptitudes. You can stimulate one boy with experiments that require insight and imagination; you can develop executive power and enthusiasm in another by things that are intensely practical.

Mr. Abrahams said that he thought the public school system ought to be remodelled on the theory that each school which the pupil entered was to be the last that that individual might have an opportunity to attend. I think he is right. I am certain that he is so far as the public high school is concerned. A majority of the boys in secondary schools do not go to college, and the school curriculum and the teaching ought to be reorganized from start to finish with this fact in view. There ought to be all along the line good getting-off places for pupils who are forced for one reason or another to withdraw. Teaching the Greek alphabet may be immensely useful, indeed absolutely essential to the boy who is going to study Greek for a number of years thereafter; but imagine how futile it would be to teach it to the boy who must stop just as soon as he has learned his alphabet. He appreciates the absurdity of it and loses his respect for the teacher and the school. I do not hesitate to assert that the damage done to such a boy by giving him part of a continuous course, when it is evident that he cannot continue it far enough to reap the harvest, is a great deal more serious than the damage which would be done to a boy who will have an opportunity for continuous training if his instruction is given to him in separate units. In the second instance I am not even sure that there would be any disadvantage at all. I think, therefore, that Mr. Abrahams is absolutely right in his statement that our point of view should be in the main that when a boy enters a class in physics or a class

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in chemistry in a secondary school his teacher should assume that this is the last opportunity that anybody may ever have to teach that boy anything of science.

There are other points in the morning addresses which I should like to refer to, but I must pass on to consider the program of the afternoon.

First, I want to thank Dr. Bumpus for the clear and positive way in which he said something that I have always believed, namely, that colleges would far rather have real ability in applicants for admission than technical qualifications or skill in passing entrance examinations. I have never heard another college president say it with equal frankness, and I think we are all indebted to Dr. Bumpus for giving the emphasis to this fact which he did. He has certainly encouraged all science teachers to use their best thought and judgment in working out the problems for the high school on the theory that, if they do the best that is possible for the high school, it will be equally satisfactory for the college, because the entire tone and character of the education upon which the college rests will have been raised.

Dr. Bumpus endorsed Mr. Abrahams when he again clearly and forcefully pointed out the impossibility of taking into account in high school teaching the differences between different boys and different girls. What he said in this regard cannot, I think, be taken too seriously to heart.

Dean Anthony called attention, as I did a moment ago, to the splendid possibilities which the science laboratories offer the teacher for getting individual contact with pupils and for stimulating each one at the point where that particular pupil can be most successfully reached. He also called attention to the advantage of teaching all science just as far as possible through the laboratory method. I wish to supplement what he said by only a single thought. Too often, as I have seen high school science taught, the laboratory has been used simply to prove that the text book was right. I know of nothing that creates in a vigorous boy more of contempt than that particular method. To give him a text book, to require him to learn what it says because it is right and true, to have his teacher endorse every statement, and then to send him into the laboratory, and with imperfect apparatus to ask him to prove it all, seems to him little short of ridiculous. It all appears to him so silly. In many cases, too, the boy knew most of it before being taught. Most boys know something about levers and pulleys, about motion and friction, and when a laboratory is used as a means of proving to such boys that something that the teacher and the text book both told him was right and that he knew was right in the beginning, it decreases his respect for the subject and for the school.

If, on the other hand, the boy is turned loose in the laboratory to find out things for himself and the text book is used as a sort of sum-

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mation of the experience that he has acquired in the laboratory, his sensations will be totally different. Let me repeat an anecdote from my own experience. This happened in the third year of my course in the Massachusetts Institute of Technology. One of my professors was very much interested in the subject of measuring high temperatures by means of platinum balls, and he asked me and one of my classmates if we would not devote our regular laboratory time to a careful investigation of the accuracy and usefulness of that method of measurement. I hardly know how to account for his being willing to excuse us from all the regular work or for his being willing to trust us with a man's task. We were only inexperienced boys just coming into the laboratory. This experience was an extremely small fraction of a year's work but it has always stood out in my mind as being the most valuable one of my entire course. I would not be willing to exchange it for anything else gained in five times the amount of time.

At the end of that investigation my classmate and I knew more about that particular method of temperature measurement than anyone else in Boston. It was worth a year's work to get that sensation, and as I contrast what we two derived from our term's work in the laboratory with what the rest of my classmates received, the contrast is pathetic. The rest were doing the regular work, proving that the text book was right, by the methods with which you are all too familiar.

In conclusion, I wish to refer to Dean Anthony's story regarding the value of technical training being 75% in the development of character. I was surprised to hear him say 75% instead of 95. I am sure, however, that Dean Anthony will accept this amendment. The development of character is the purpose of all our work. If we do nothing in that direction our total accomplishment is very small.

Now the one thing that I would like to ask you science teachers to do when you go back home is to read over the lessons and the laboratory exercises that you have been giving since last September, and are planning to give between now and June. Take them lesson by lesson, one at a time. There is character development, of course, in doing disagreeable things when one does them with a will. There is character development in doing stupid things when one does them with a smile and the very best of one's ability. But how about it when the spirit is "just to get by." How many experiments and lessons tend to develop this latter spirit, especially those which appear to pupils as being not worth while. Most of us have been in the habit of being content with the feeling that our instruction necessarily developed character, but what proportion of it really does so?

Please take the lessons, therefore, one by one, and ask yourselves how much of real inspiration—especially for the stupid boy—is there in lesson one, is there in lesson two, or three? How much of the idealism that Dr. Dole talked about today; how much of genuine

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appeal to the practical common sense of the boys and girls; and how much of their real development of character that Dean Anthony described; and then see if you cannot in at least one or two or three places in the course, and as many more as possible, substitute something else that will have more in it of that vitality and stimulating influence that science has had in universities and in the elementary school work. I have the utmost faith in the benefits of education and I have an equal faith in science; I have faith in boys and girls, especially in boys and girls of high school age; and I have great faith in the purpose and ability of secondary school teachers. My own belief is that another generation is going to see a very different kind of results from science teaching. But why should we postpone for a generation the day when secondary school science teaching shall come into its own?

The meeting closed with a rising vote of thanks to the various speakers for their excellent addresses, and to those of the Medford High School who did so much in the way of making our meeting one of the most successful in the history of the Association.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SEVENTY-FIRST REGULAR MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, May 22, 1915

at St. Paul's School, Concord, New Hampshire.

10.30 A.M.
Meeting of the Executive Committee.

10.45 A.M.
Business session.
Reports of Standing Committees.
Election of New Members.

11.15 A.M.
Address of Welcome.
Rev. Samuel S. Drury, Rector of St. Paul's School.

11.30 A.M.
Address: "The Reflection of X-Rays from Crystalline Surfaces." Prof. G. F. Hull, Department of Physics, Dartmouth College.

1.00 P.M.
Lunch.

2.00 P.M.
Address: "Transcontinental Telephony." Mr. J. G. Patterson, Engineer of the New England Telephone and Telegraph Co., Boston.

3.00 P.M.
Address: "Methods of Projecting Lecture Experiments." Prof. Willard J. Fisher, Department of Physics, New Hampshire State College.

4.00 P.M.
Inspection of school plant.

4.30 P.M.
Leave school for the station.

5.00 P.M.
Train for Boston.

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MORNING SESSION

The meeting was called to order by President Hall who called for the

REPORT OF THE COMMITTEE ON NEW APPARATUS.
R. C. Lowell, *Chairman.*

Mr. Hall showed a piece of apparatus for teaching laws of resistance of wires. It consists of a board on which are fastened wires of Nisil and copper of same size but different lengths and in the case of the Nisil, of single, double and triple strands. BC is single Nisil,

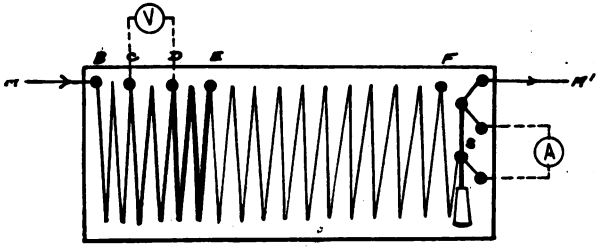

FIG. 1.

CD is double strand Nisil, same length, giving the double cross sectional area, DE is triple strand Nisil, same length, giving three times the cross sectional area. EF is copper, longer, but of same size as the single Nisil wire. The whole is in series in a circuit with nine other stations, with about 5 amperes flowing. Five amperes will heat up the high resistance Nisil, but will not raise the temperature of the same size copper wire appreciably, thus incidentally showing the heating effect with high resistance.

The switch S, when down, short circuits out the ammeter, thus allowing the ammeter to be removed to be used as a voltmeter by connecting to its other binding posts, as shown at CD. We use the Weston miniature combination volt and ammeter, range 0-6 volts, 0-6 amperes. Also, this switch shows the proper method of connecting an ammeter for commercial testing, so that the ammeter shall not be subjected to the continuous heating effect of the current when one is not reading the instrument. When the switch is open, the current passes through the ammeter and we may read the current in the wires.

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After the current is read, the switch is closed, and the drop in volts read across the sections, BC, CD, DE, and EF.

By ohm's law, then, one may find the resistance of the respective sections.

The first section, BC, has actually several more subsections, not shown on the drawing, so one may by comparing drops across them, see that the resistance is proportional to length.

By comparing BC, CD, and DE, we get the relative resistance of single, double and triple cross sections.

By comparing a unit section of EF, which is copper, with the same unit of BC, we get the effect of material, the Nisil showing some thirty times as much resistance as copper.

A student used only fifteen minutes in making all readings for the exercise.

One may, of course, connect M. M.' across low-voltage mains in parallel, using about 5 volts.

This, however, with ten pieces, means some 50 amperes, as they are in parallel, and quite a large main to carry it, but in the series scheme, one may use an ordinary No. 14 wire for the mains. No trouble is experienced with the slight change of resistance in the line as the switches are thrown up or down, since the total resistance of the short circuited ammeter is not much different from the ammeter alone.

Mr. Lowell showed the piece of apparatus put out by Knott, No. 20-25, for determining the specific gravity of a gas by the rate of flow through an opening. This assumes the rate of flow to be inversely proportional to the specific gravity of the gas.

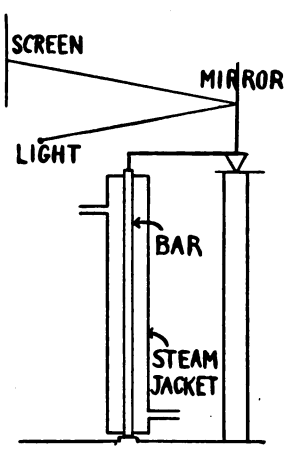

Fig 2.

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He also showed a lecture table co-efficient of linear expansion apparatus. In this the metal tube, see figure, enclosed in a steam jacket is in an upright position. On this, at the top, rests one end of a right-angled frame, the other arm being an upright mirror. With a light thrown upon this mirror, the movement of a spot of light on a screen shows the changing length of the bar. With the length of the arms, and the distance of the screen known, the change in length of the bar may be calculated.

Mr. Lowell showed Knott's latest form of electromagnet. This is on an upright frame. It can be moved up and down, and cramped at any desired distance above the table. It operates on the 110-volt house circuit, and is capable of lifting two hundred pounds.

Mr. Lowell closed by calling attention to Knott's electrical-driven rotator with variable speed regulator. This was used in the afternoon by Dr. Fisher of New Hampshire College.

Following is the

REPORT OF THE COMMITTEE ON CURRENT EVENTS IN PHYSICS.
Roger C. Chittenden, *Chairman.*

Laboratory tests have shown that escaping illuminating gas unites chemically with asphalt pavements, thus softening and deteriorating them.

Good cement is now made in France from by-products in the process of making beet-sugar. To the scum from the boiling beets is added fine clay, and the whole is burned like Portland cement. The resulting clinker is pulverized into cement.

Four hundred and ninety-six ships passed through the Panama canal during the first six months.

The U. S. S. *California*, to be finished in two years, is to be driven by electricity. The turbines will transmit power to slow-moving motors.

There are two waterfalls in Iceland which, it is estimated, could produce 60,000 and 50,000 H.P. respectively.

Wm. Marconi has sailed for Italy to take charge of the entire wireless system there. Marconi has developed a system of wireless telephony which is to be used in the Italian fleet and probably in the British. It has been successfully used between New York and Philadelphia, and Marconi expects, on perfecting details, to be able to transmit speech across the Atlantic.

Marconi has invented an apparatus by means of which a person standing beside a solid partition can look through and see what is happening on the other side.

The Packard Motor Car Co. has put out a 12-cylinder car; twin-sixes.

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A magnetic nail packer which arranges nails in parallel rows is now on sale. It works on the principle that moving iron objects adjust themselves in the direction of the lines of force.

X-rays are now used during the process of operations for extracting bullets, etc.

Red-cross aeroplanes are now fitted with wire ambulances for carrying wounded soldiers, and also a folding table for imperative operations.

The Connecticut Aircraft Co. has bought the patent rights for aeroplane construction from the Wright Co. Orville Wright will now give his whole time to scientific work in aviation.

The Lackawanna railroad is moving trains between Scranton and Binghampton, N. Y., a distance of 63 miles, by wireless telephone. They expect soon to include Hoboken, 150 miles away.

Boston is now sprinkling some of its streets with an electric tank car fitted with long side arms. They are also trying out a steel watering cart from which the water, under pressure, thoroughly flushes the streets.

The discovery of a new radio-active element, named brevium, resulting from the disintegration of uranium, is announced by Professor Goehring, of the Physico-Chemical Institute at Karlsruhe.

On recommendation of the Executive Committee, Mr. Walter M. Heald of Wentworth Institute was elected an active member of the Association.

Reverend Samuel S. Drury, Rector of St. Paul's School, then delivered an

Address of Welcome.

Gentlemen:

It is always pleasant to welcome friends to this School, and specially we like to welcome those who are interested in education. It does us good to have you here; for boarding schools must remember where to place their emphasis,—they exist as *schools* and not as rural resorts. At a place like this we must persistently emphasize the noun "school," and let the adjective, with all that it connotes, take its important but secondary place.

Day schools and schools of this sort are converging toward a significant similarity. The high school used to say: "We are concerned only with a boy's *head*, for five hours a day." The boarding school used blandly to reply: "Our ideal is a young gentleman with broad shoulders."

Now-a-days we hear of "country day schools," and we note that the high schools have worked downwards from a boy's head and are developing his shoulders,—whereas the boarding school is work-

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ing precisely the other way. And we are all agreeing on a human product who shows suitable development in body and in mind. The boarding school teachers and day school teachers have therefore perhaps more in common than a decade ago. We are working for the sane mind in the sound body, the alert mind in the controlled body, at times like these for the intrepid mind in the ascetic body, and always for the productive mind in the serviceable body.

Again, gentlemen, it is helpful to have you here for we shall profit by the pressure of your experience. "Science" is a most responsible subject, which only the best men should essay to teach. I know that yours is an association of reverent transmitters of truth. Let us remember that it is specially in the laboratory and in the chapel that youth confronts truth. In both places we contemplate mysterious and majestic law. Alike before the lecture-table and the altar the expanding mind of boyhood begins to ask questions, begins to doubt, begins to build a creed. Let the men who are teaching Science, in whatever branch realize how closely the special truth they impart applies to a man's whole career and view of life. As in the chapel men of God proclaim that all's love but all's law," so may you grasp your opportunity and lead your scholars to believe that though all's law, all's love.

Professor G. F. Hall of Dartmouth College then delivered an address on

"The Reflection of X-Rays from Crystalline Surfaces."

Immediately after the discovery of x-rays, almost twenty years ago, experiments were undertaken designed to test their nature. It seemed probable that they were light waves, but they did not exhibit the ordinary characteristics of light; that is to say, they were not regularly reflected, refracted or polarized. On the other hand they evidently were not like cathode rays—negatively charged particles—nor were they positively charged like the Alpha rays from the newly discovered radium. Professor Bragg set forth the view that they were electrically neutral particles,—doublets, as he called them—and following the famous example of Newton, he proceeded to explain all the known properties of x-rays on the basis of this new corpuscular theory. Notwithstanding Professor Bragg's able pleading for his theory, and in spite of the failure of experiments to prove their identity with light, x-rays continued to be regarded as short ether waves. We have not time here to review the experiment by Haga and Windt which claimed to show that x-rays were ether waves of extremely short wave length, nor the experiments by Barkla showing that under certain conditions x-rays were polarized. We come at once to the brilliant experiment designed by Dr. Laue of Zurich, and performed by Friederick and Knipping.

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In the ordinary experiment on the diffraction of light, the grating space used is about two or three times the wave length. It is clear that if x-rays are of very short wave length no grating can be made which will have a grating space of their order of magnitude. Dr. Laue conceived the idea of using the ordered arrangement of the atoms or molecules of a crystal as a space grating. The results of the experiment brilliantly confirmed his idea. A small pencil of x-rays was allowed to pass through a thin crystal on its way to a photographic plate. The effect on the plate is shown by the diagram, Fig. 1.

Fig. 1.

An analogous experiment in light might be shown by passing a beam of light through a number of planes equally spaced, each plane consisting of a set of rectangular apertures or of crossed gratings.

Here spots of light are found in definite positions on the screen. From the arrangement of the spots and from the known distances between apertures and planes the wave length of light can be calculated. The mathematical analysis in the case of x-rays is difficult, and the interpretation more or less doubtful.

Professor Bragg regarded the spots as due to the reinforced reflection or scattering from similar planes. The analogous phenomenon in light would be the reflection of light from a soap film.

Here given a certain direction of incident light upon the film, red light is copiously reflected in one direction and blue in another. The reflection of x-rays, however, differs from that of light in being dependent not upon the surface of separation of crystal and air, but upon reinforced reflection from successive planes.

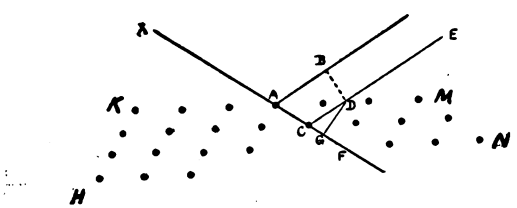

Fig. 2.

Let us consider a beam of x-rays (XA) falling upon a crystal, as in Fig. 2. That part which goes on to C and is reflected along

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CDE will reinforce the part reflected along AB when AC + CD — AB = 1 (one wave length), *i.e.*, when GF = 1, or when $1 = 2d \sin \theta_1$. Had the difference of path been 2l there would also have been reinforcement when $2l = 2d \sin \theta_2$. In general there would be a maximum reflected energy when $nl = 2d \sin \theta_n$ --n being 1, 2, 3, - - - - - - for the first, second, third ------- orders. Now a crystal whose atoms are arranged as in Fig. 2 may have a number of natural faces as shown by the contour. It is evident by inspection that the distance between the planes parallel to HK differs from that between those parallel to KM, and this again from that between the planes parallel to MN. Hence if we use the same wave length of x-rays we would obtain different values of θ for the different faces of the crystal. Moreover, the density of the atoms in the KM planes is greater than that in the other planes, consequently the intensity of the rays reflected from that face would be greater than the intensity from either of the other faces. Hence we are able by noting the position and intensity of the reflected rays to determine the arrangement of the atoms in the planes and the distances between the latter.

Let us now suppose that the crystal is a cubic, say NaCl. Suppose that the atoms are arranged in the corners of a cube as shown

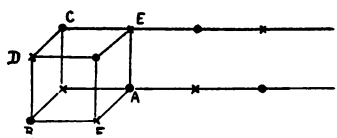

FIG. 3.

(Fig. 3), the dots being sodium atoms and the crosses chlorine. Let d be the distance between the (100) planes COBD, AFGE. Then the distance between the (110) plane CEFB and parallel plane is $\frac{OD}{2} = \frac{d\sqrt{2}}{2} = \frac{d}{\sqrt{2}}$. Similarly the distances between the (111) planes ABC, FDE is equal to $OG/3 = \frac{d}{\sqrt{3}}$.

Now a cubic crystal can be cut or cleaved parallel to any of these planes. If then the same kind of x-rays were reflected from these three faces, the angles for maximum reflection would be connected by the relation $\sin \theta : \sin \theta' : \sin \theta''$ as $1 : \sqrt{2} : \sqrt{3}$.

The intensity and angle of the scattered x-rays may be measured in one of two yays.

Let a beam of x-ray which has passed through a very small opening at X in a lead screen fall upon a crystal C. Then we may use a photographic plate P or an ionization chamber I to measure the intensity of the scattered energy. C would have to be at the

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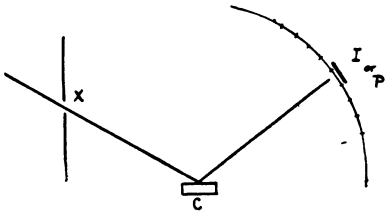

FIG. 4.

centre of a graduated circle around which P or I moved. Evidently as C is turned, CP or CI must turn twice as fast.

Professor Bragg measured the angles giving the maximum reflection from the three faces (100, 110, 111) of rock salt and found that the ratios of the sines of the angles were to each other very nearly as $1 : \sqrt{2} : \sqrt{3}$. This evidence, together with similar evidence using other cubic crystals, notably sylvine (KCL), was conclusive regarding the distances between the planes.

There is another point which ought to be taken into consideration in this discussion. It has been shown by Barkla and others that the intensity of the x-rays scattered from an atom is a function of its atomic weight. Now the planes OB, DC, EF, B'C contain equal numbers of Na and Cl atoms, while the planes ABC (111) contain alternately all Na and all Cl. This fact gives us new information concerning the natures of the reflected energy from the various faces and the experimental results are found to be in accord with the calculated effects.

We are evidently able then, using a constant beam of x-rays whose wave length we need not know, to determine the *relative* distances between the various planes of a crystal and also the probable arrangement of the atoms in those planes. If we are able to measure the absolute distance between the planes for any crystal we are then able to measure the distances for all planes for all crystals, and we are also able to measure the wave length of the x-radiation from all elements using the relation $l = 2d \sin \theta$.

It is evident then that this study may lead us in one direction to the opening up of an entirely new field in crystallography or in the other direction to an extraordinary extension of our knowledge of radiation from the elements. As an illustration of the application of the study to crystallography, let us calculate the distance between the atoms of rock salt. Professor Bragg's experiments have shown that the sodium or chlorine atoms are arranged on the corners of a cube, as in Fig. 3. Let d = distance between atoms. Then the number of molecules in one gm. mol. (58.5 gms.) $= 6 \times 10^{23}$ Hence the number in 1 cc. (2.18 gms.) $= 6 \times 10^{23} \times 2.18$

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x58.5. But the number of molecules $= \frac{1}{2d^3}$. Hence d = 2.81 x 10^{-8} cm. Thus the absolute distance for the 100 plane for rock salt being known the distances for all other crystals are known. Moreover, the wave length of the most intense radiation, from platinum for example, is at once measurable. It is 1.10×10^{-8} cm.

We have not time to follow the subject into the details of crystallography, nor have we time to go in the other direction—the study of the x-radiation from the elements. We may here merely summarize one general result. Moasley has found that there is a linear relation between the square roots of the frequencies of the corresponding x-radiations from the elements and their order in the periodic table. The latter is called the atomic member. It is roughly equal to one-half the atomic weight.

Hence we have in x-rays a new tool by means of which we may not only disclose the positions and distances apart of the various atoms of a crystal, but also may learn facts leading us to a knowledge of the inter-relation and structure of the atoms themselves.

During the noon recess an opportunity was given to look about the science laboratory of the school. The neatness and care with which the apparatus was kept, together with the completeness of the equipment, was very noticeable.

Lunch was served in the dining room of the upper school, which consists of the two upper classes. This lunch was unique in that it was served in conjunction with that served to the boys of the school, a most enjoyable novelty.

AFTERNOON SESSION

Mr. J. G. Patterson, engineer of the New England Telephone & Telegraph Company, delivered a very interesting address on

TRANSCONTINENTAL TELEPHONY.

The all-embracing problem of telephony has been well summed up by our engineer, Bancroft Gherardi, in three factors which are (changing his wording slightly), 1st, to connect with speed and accuracy; 2nd, to transmit speech distinctly; 3rd, to make the cost as low as economical. Out of these grow the multitude of specific problems of which the engineering phases will probably be most

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interesting to you. The transcontinental service is the culmination of efforts to date, but that it is not the end we are confident. This accomplishment represents the sum of many improvements in various parts going to form the complete connection—transmitter, receiver, switchboard, cords, relays, open wire lines, cables, in fact every link in the chain.

It is true that many of the items of equipment involved in these problems are small, taken separately, but when the number of units is considered, the magnitude of the problems, both in extent and value, becomes apparent. There are, for example, a million miles of wire in the New England Company alone, covering a part of four states; in the United States (Bell System) 17½ million miles. Consider substation telephone sets. There are one-half a million in the New England Company or nearly nine million in the Bell System. All of this calls for careful engineering in selection of material, manufacturing and inspection, detailed planning for economy, good workmanship in constructing and painstaking maintenance. And the values of plant built up in this way run up to about seventy million in the New England Company and nearly nine hundred million in the Bell System.

The Panama Canal cost nearly $300,000,000, but while that was being built, there was expended on Bell Telephone Plant in the United States for construction about twice the cost of the Canal. These facts are given in order that you may not lose sight of the extent of application while we go on to look at some of the problems at closer range.

Take the telephone instruments, receiver and transmitter. The receiver corresponds, of course, to the original telephone invented by Bell. It has changed in principle as little perhaps as any other piece of telephone equipment, yet there have been, between 1877 and 1914, fifty-three types and styles of receivers in use, excluding minor improvements. The ordinary form consists of a permanent magnet of an elongated horse-shoe type, with soft iron pole pieces wound to form an electro-magnet which actuates the diaphragm. The tempering of the permanent magnet formerly required the attention of skilled men to insure proper heat; equally fine temper is now obtained by placing the steel for a prescribed time in a furnace equipped with an electrical indicator. Dimensions are very important. If the diaphragm varied in thickness more than one-thousandth of an inch from standard, or if the separation between diaphragm and pole pieces varied more than one-thousandth, the results would not be satisfactory.

Between the 1877 type of transmitter and the present, the path of progress is marked by seventy-three types and styles. The present type is familiar to you all, its essential principle being to produce electric current varing in amount precisely as the density of the

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air varies during the production of a sound. The sound waves in air strike a diaphragm which operates to compress carbon-granules in a chamber attached, thus varying the resistance in a battery circuit and, therefore, varying the current. The present type of transmitter is the outgrowth of much research, the seventy-three types and styles just now referred to being varieties put into service and representing only a small fraction of the laboratory experimental types. In early researches on telephony diaphragms were tried, varying in size from an ear drum up to a bass drum, final type being considerably nearer the ear drum size. To illustrate the delicacy of this problem, the mica, which forms an important part of the transmitter, can be found of proper quality only in India. Its dimensions must be held within three-ten-thousandths of an inch, and owing to the difficulty in separating even this selected stock, about 80% of it is rejected. With the present transmitter the voltage impressed on the circuit at the sending end is usually not over five volts, and may be considerably less, although it may be necessary to use forty-eight volts at the central office to produce this, owing to line drop. The current produced varies, of course, with different kinds of lines, but may be taken as about five-thousandths of an ampere (five milliamperes) or less. This, please bear in mind, is at the talking end. The amount at the receiving end, in a typical case, is 10% of this, or five-ten-thousandths of an ampere.

With all this delicacy the manufacture of transmitters and receivers require in one year 1500 tons of brass, 300 tons of steel, 200 tons of copper and 35,000,000 screws. To improve such instruments is no mean problem, dealing with very delicate parts and very large quantities.

In attempting to increase the effectiveness of the instruments no small part of the problem is to make sure that the properties and adjustments will last. The permanent magnet must not lose its magnetization and the soft iron of the electromagnet must not retain magnetism. Efforts of the engineers of the American Telephone Company and the Western Electric Company, covering a number of years, have, however, resulted in considerable improvement in both instruments. The new receiver is an improvement mechanically, parts of the magnet being electrically welded and more accessible and the binding posts being concealed. It is also more efficient electrically by an amount equal to extending the talking range on long distance circuits by 136 miles, a decided help on a long connection. Great progress has been made in putting these instruments into service.

Various extremely powerful transmitters have been proposed for use in telephony and have been actually used in wireless telephony and for loud speaking or announcing telephones. In addition to the difficulty of making satisfactory transmitters of this type, there

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are two controlling difficulties in the way of such instruments. These are, first, the excessive cost of the instruments, and cost of power to run them, since they would have to be supplied to each user of the telephone, and, second, the fact that the large amount of power put on the lines by them would cause interference into adjacent lines unless extensive reconstruction of all parts of the plant should be made which would be not only expensive to make but difficult to maintain.

Where underground conduit has been built on account of the number of wires warranting underground cables, or municipal authorities requiring it, we frequently have to consider how we can get the greatest possible number of wires in existing ducts to avoid opening an expensive pavement. One of the recent accomplishments in this line is a 900 pair cable, 1800 wires, No. 22 B. & S., plus a few extras, in a lead sheath 2 5-8 inches in diameter. And it is not merely a question of squeezing these wires into a lead pipe which would not be especially remarkable. They have to meet rigid electrical requirements as to capacity, insulation, break-down voltage and absence of crosstalk. Even the 900 pair cable is being surpassed by the 1200 pair with the same size sheath, although this involves the use of smaller wires. A 1200 pair cable would replace twelve 200-wire lines of 20 crossarms each, that is, it would carry as many circuits as 12 such lines, although the talking qualities would not be as good for long distance purposes but would be ample for local use.

The improved sheath, itself, is another answer to an urgent question. Formerly 3% tin was used in lead sheath to give strength and flexibility. In 1912 the price of tin was soaring around $0.47 a pound. As a result of study, antimony was tried in place of the tin. Electrical, chemical and mechanical tests were made. Acids, electrolysis by stray currents, bending, pulling in and out of ducts under severe conditions, vibrations on elevated railway structures—in all these antimony came out the equal and superior of tin for all practical purposes.

In the central office there are interesting questions connected with the reduction of the electrical losses in the apparatus, mechanical improvements and economies in manufacture. These are incidental to the larger developments which have resulted in changing practically all the switchboards several times in the last 25 years, and the end is not yet.

The so-called automatic switchboard is not yet a commercial success under all conditions. It is not really automatic, as the subscriber is the operator and the number of additional trouble-men to take care of the complex apparatus goes far toward offsetting the saving in switchboard operators, and the higher first cost results in greater interest and other fixed charges. We are, however,

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rapidly making the operations automatic as far as economy can be shown. Automatic ringing, for example, starts on plugging-in without the operation of special ringing keys, in fact, cord circuits have been devised which provide automatic listening when the operator plugs in to answer a call and when she plugs in to the called line, the automatic apparatus cuts off the listening and rings the called subscriber. A new switchboard cord is now in use which replaces former types of steel and tinsel cords. It is a tinsel cord of rope construction, made by twisting together three strands of six threads each. Three such conductors, insulated with silk and treated with a moisture-proof compound and covered with braid, form a cord. This has several advantages:—

1. It eliminates fire risk owing to its low resistance and non-heating properties.
2. It extends the transmission range about 30 miles on long distance lines as compared to the old steel cord.
3. It increases the speed of connection owing to its greater flexibility.
4. It is moisture-proof, a valuable property in sea-coast cities, or other localities where the humidity is high.

Tests showed 75,000 operations to be the approximate life of these cords. These tests were made by hand plugging-up and unplugging. This required a force of boys for a considerable time and was not, you may be sure, a popular job with them.

The cord circuit is a term for the wiring and apparatus used in connection with the cord, for the purpose of giving signals to disconnect or come in, or as we say to supervise. Improvements have been made in both local and long distance cord circuits. In the local circuit the relay or electromagnet, controlling the signal lamp, has been improved in fineness of adjustment, decreasing maintenance and reducing resistance, thus improving the transmission. On the toll switchboard, we have the new high impedance cord circuit with new type of relay. This is adapted to the higher voltage of transmission on lines loaded with Pupin coils to be explained presently. The result is a decrease in the loss, due to apparatus bridging across the line and therefore, an increase in the talking distance. The old cord circuit had a loss equal to 68 miles of high grade line; the new one less than 2 miles, or 66 miles nearer San Francisco for every cord in the connection. When it is known that each mile of talking range gained by improving the line costs about $14.50 a year on these high grade circuits, it may be realized what a great saving has been made.

But it is in the line itself, that the greatest gain has been made. It is not a question simply of more "juice" or loudness of transmitter or receiver, it is an alternating current multi-frequency prob-

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lem. Long distance telephone lines are longer than power lines, both mechanically in miles and electrically in number of waves on the line, so that the alternating current line losses consume most of the power. The waves are of complex shape, complexities which are not to be ironed out as undesirable but to be preserved as essential characteristics of the sound. Each person's voice, as well as each sound, is recognized by these complexities. These waves of intricate shape bearing the characteristics, both of the speaker and of the spoken word, are of various frequencies, from 100 to 2000 per second being the essential range. The high frequencies travel faster and decrease in size more rapidly, distorting the shape of the wave so that the ear can not recognize it when changed back to an air wave. The overtones giving quality are lost, being worn down smooth by line losses.

A word in explanation of these losses. There are four fundamental properties of the line affecting transmission: resistance, inductance, capacity and leakage (the reciprocal of insulation). Most lines, before loading, have very little inductance so that the line losses are due mainly to resistance, capacity and leakage. The capacity is more important on cable lines, owing to the small separation between the wires. The leakage is of a special importance on open wire or aerial lines, owing to exposure to wet weather. The problem then, is to decrease these line losses.

The resistance was reduced by increasing the size of wire. The largest economical size of wire in cable is No. 10 B. & S. With this size it is just about the limit to talk a little over fifty miles, allowing for apparatus and lines to the central office or by getting right on the end of the wire with the telephone set, seventy-five miles could be reached. The capacity was reduced by using paper and air space insulation instead of solid rubber. It was even proposed to decrease the insulation resistance, that is, increase the leakage by the use of shunts across the line. A better and cheaper method was discovered about 1899 by Professor M. I. Pupin. This method was to add inductance at regular intervals close enough together to approximate a uniform line electrically. In mechanical analogy it is like putting weights on a rope. One separate weight simply acts as a drag, interfering with the vibrations, but if a number of weights are put on close enough together, it acts like a heavy rope and the range of vibration is extended. In electric loading for telephone currents, if each wave at 800 cycles includes nine coils, the effect is practically that of a uniform line. This means that coils on cable should be from one to three miles apart and about eight miles on open wire. They range in size from four to ten inches in diameter, and are usually installed in cast iron cases, or from fifteen to one hundred coils in cable and an open wire in small cases similiar to small electric light transformers. The core of these coils is made up of fine

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enameled iron wire about four thousandths of an inch in diameter that is, about the thickness of a sheet of note paper.

This loading increases the impedance of the line, allowing the transmission of power at higher voltage with decreasing current and less line losses. At the same time, the increased voltage tends to increase the loss on open wire lines, due to leakage and much study had to be given to improve the insulation. Careful treating of trees, purchase of private right-of-way, improved insulators, special insulators for bridle or leading-in wires, were some of the precautions required. The transmission efficiency of a loading line decreases more rapidly when the insulation is lowered than that of a non-loaded line. Near Salt Lake, on the transcontinental line, a crust of salt was found to form in damp weather, resulting in low insulation. A special machine, burning kerosene, was devised to go along a line and force a jet of steam across the insulators to wash off this coating.

Obviously, when the line is made to deliver more power, it delivers more of the disturbing induced currents picked up from other lines. An induced current of 300 cycles per second, amounting to 10 millionths of an ampere, makes it as difficult to hear as the addition of about 300 miles of long distance circuit to the connection, that is, it reduces the talking range about 300 miles. The increased sensitiveness to disturbance had to be met by greater refinement in transposing the wires and accurate spacing of the loading coils.

The loading of our largest size open wires gave enough improvement to extend the talking limit from 850 to 2000 miles, like taking a long step from Chicago to Denver. On cables the limit was stretched from 75 miles to 525 miles, extending our underground range, for example, to Washington, but as you can see, cable is not good enough for San Francisco and the amount in the transcontinental line has to be kept down to a minimum. By means of loading, a greater proportionate gain is obtained on cable than on open wire on account of the greater capacity offset by the induction coils. For the same reason, in addition to the gain in volume there is a marked improvement in clearness. Loading has developed until there are now over 18,000 coils in New England alone. Loading has also been applied to submarine cable. This is the solution of a very difficult problem. Cases containing the coils are heavy, weighing as much as one-half a ton. The joint between the rigid case and the flexible cable is somewhat complex,—in order to preserve the continuity of the lead covering and the strength of the armor wires. These mechanical problems might be avoided by continuous loading, consisting of a wrapping of iron wire around the conductor, but unfortunately this does not produce enough inductance to compensate for the increased diameter of the conductor, particularly in cables consisting of a number of pairs, although it is in use on several very

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important cables, one of the English Channel cables, for example. The coil loading is also in successful use in a number of places, one of which is Chesapeake Bay where a five-mile loaded submarine cable obviated 50 miles of land line. The laying of these cables also presents some interesting problems, the cable and reels for the Chesapeake Bay crossing weighing about 120 tons.

The phantom is an interesting, though somewhat elusive, development. It is mainly a case of economy, that is, of saving wires, although there is some gain in transmission. Given four wires; "A", "B", "C", "D"; one conversation is carried on "A" and "B" constituting one pair, current going out on "A", returning on "B". The second conversation is carried by a current going out on "C" and back on "D". Now a third conversation may be carried by a current going out on "A" and "B" in parallel and back on "C" and "D" in parallel. This conversation is on the phantom. A phantom is a third talking circuit obtained on four wires by the arrangement shown. On the regular side circuits the talking or ringing currents, which are alternating or varying periodically in amount and direction, are repeated through, on the two wires composing the side circuits, by means of repeating coils or transformers. On the phantom circuit the connections to the repeating coils are made at the middle point of the outer winding. Therefore, assuming that the line wires as well as the coils are of equal resistance, inductance, capacity and insulation on each side, or properly "balanced," the current splits equally in both directions, thus neutralizing any tendency to repeat in the coils, and passing out divided on the two-line wires. Similarly at the other end the tendency to repeat is neutralized and the current on the two wires unites on the single wires carrying each side of the phantom to the jack on the switchboard. In order to avoid crosstalk it is essential that the "balance" be perfected by making all four wires as nearly alike as possible in all respects. Also, in addition to transposing or interchanging on the pins of the pole lines at specified intervals the two wires composing each side circuit, the two-side circuits themselves, each considered as one conductor of the phantom circuit, must be tranposed. The diagram shows more concretely the construction of the coil, its core, etc. It also shows how one-half a phantom is used for telegraph.

Telephone cables have now been improved by special construction to provide phantoms in the cable. These are known as duplex cables. The transposition of the side circuits is cared for as in the ordinary cable by the use of twisted pairs. The transpositions of the phantom are provided by twisting two pairs together. This is called a quad.

The loading coils for duplex cable are also a new invention, ordinary coils would not load the phantoms. The phantom coils are

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designed so as to be inductive in the phantom and non-inductive in the side circuits by means of a reversal of windings. New coils have also been designed for the side circuits which are non-inductive to the phantom.

The duplexing, or twisting together of pairs, must be carried even to the repeating coils in the office. Emergency replacements must be made with duplex cable and connected wire for wire. In making duplex cable it is desirable to have the number of quads, such as will give a symmetrical arrangement. Three and seven are numbers which lay up well.

If any of you do not find the preceding explanation of phantoms perfectly clear at first blush, to use a favorite expression of Professor Byerly, do not be alarmed, even telephone men found it a little complicated at first. When the open wire phantoms were first used, some of the linemen were much disturbed; sarcastic comments were overheard and a cartoon was drawn showing an inmate of a padded cell trying to make various types of transpositions. This, however, was supposed to be the inventor. Progress has gone on until there are now 8000 miles of phantom in the New England Company and many more possible in duplex cable, awaiting the need. It should be noted that phantoming is not at present economical on subscribers' lines in cable, or short lines about town.

And then with our standard materials and methods of construction worked out, some one has to investigate requirements and costs, to help in deciding where, when and how much to construct. This study is called the fundamental plan and in addition to electrical and mechanical developments, falls to the lot of the engineer. If the plans do not work out properly, something else is liable to fall. Not that the engineer has the only hard job. At present the man who has to raise the money has a claim on our sympathy. However, some responsibility is involved and some problems must be solved before one can determine the proper arrangement, amount and fitting together of such a plant. Enough for growth, yet not extravagant; everything first class, yet economical and conforming to all municipal and other government requirements, or else we are in hot water right away.

Just to touch on the steps in such plans. Population estimate by curves, extending fifteen or twenty years into the future, covering the United States and working down to states, cities and wards, distributing the growth. A house to house survey and detailed estimate of business possibilities. Feeding in the lines from expected telephones to the central office by the shortest route, balancing up the lines in each direction to find the best centre, comparing the value of lots actually obtainable and picking out the best. Determining how many pairs should be in the cable, how many ducts in the conduit, etc.

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For the central office, plans are made years in advance. Some of the steps necessary are counts of calls in the busy hour, calls to other offices, perhaps not established yet—as in opening a new office, determining the number of subscribers and how many parties on the various classes of lines. These data are necessary to determine the number of lines in the board or the number of jacks. Some boards do not have all jacks in front of the subscribers' operator, but when there is much outgoing business it may be transferred to another operator, thus saving duplication of equipment. It is necessary to determine the number of positions for operators, a high rate of calling requiring more positions for the same number of lines, as in a business district. Power plant must be provided for the peak load, machines, power switchboards, storage battery with reserve power to carry in case of loss of outside power. Floor plans must be made, showing the location of all this apparatus. Questions arise such as whether it is better to have one or two boards in an existing building or to dispose of the existing equipment and building and start fresh.

Similar plans for toll lines and switchboards must be made. After the standard grade of talk has been determined, length of haul, destination and volume of the traffic must be found. The proper transmission requires a certain size of wire and often loading. The proper grades of circuit must be grouped together into routes, pole lines planned and cables. Then the right-of-way man can go after a certain location and he has some problems of his own.

Of the problems caused by electrolysis or damage to plant by stray power currents and of interference or induction, I shall not say much as it is not so new a story. The damage from storms is also familiar to you. The protection of the telephone plant from such damage is especially essential to the maintenance of such long lines as the transcontinental.

The construction of such lines as the Boston-Washington underground or the transcontinental line, deserves an entire paper on each one. The Washington line is 475 miles long. A good many things may happen to 475 miles of line; a storm did happen when President Taft was inaugurated, result—no news. Steps taken to prevent recurrence—put the line underground. For some parts where there was existing cable it was not replaced, but with these replacements made the completed cost approximates $5,000,000. An interesting development in connection with this line is the trench digging machine which was used where conditions allowed. This operated in good digging at three feet per minute. In many places it could not be used on account of rock. The type of cable used consisted of seven quads (14 pairs) No. 10 B. & S., with six pairs 13 gauge, in the interstices, and around this 18 quads (36 pairs) of 13 guage with 18 pairs of No. 16, in the interstices. The talking equiva-

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lent on the No. 10 phantom is equivalent to 26 miles of 19 gauge cable between test boards. The smaller sizes of wire are used for intermediate distances and for patching open wires in case of a break.

We have now reached a point where a general description of the transcontinental line may be better understood. From Boston to San Francisco, a distance of 3505 miles, the lines consist of two physical or side circuits, and one phantom, all loaded. The wire is No. 8 B. W. G., about one-sixth of an inch in diameter, weighing 435 pounds per mile of wire; that is equivalent to about No. 6 Brown & Sharpe. The total number of poles is 130,000, the weight of wire 3000 tons. The loading coils require 13,600 miles of fine wire in the cores. The speed of transmission is 56,000 miles per second, requiring 1/15 of a second for the trip. Sound would take about four hours. San Francisco time is three hours earlier. Let us make a little time table.

	Leave Boston Boston Time.	Arrive at San Francisco San Francisco Time.
By the sound or air line.....	6 P.M.	7. P.M.
By telephone or electric line.....	6 P.M.	1/15 sec. after 3 P.M.

By telephone route this is about three hours earlier than when we started, less 1/15 of a second.

Or, by telephone.....	9 P.M.	1/15 sec. after 6 P.M.

That is, if a man could shout loudly enough, we could give him the three hours' difference in time as a handicap and still beat him by an hour—less 1/15 of a second.

Interesting experiences are related by our construction men in meeting the problems of building the new portion of the line through Nevada and Utah. All poles had to be hauled, as it was not desired, on account of inductive interference, to build the line nearer than 1000 feet or at least 300 feet from any other line, including telegraph lines on the railroad.

The poles are redwood. They were standing uncut in the forest on Janury 1, 1914, and the constructor's problem was to have them cut, sawed, hauled, set up and equipped with wires by July 1st. It was evident that digging the holes by hand would be too slow and a post-hole digging machine was used. This dug holes 16 inches in diameter and 4½ feet deep in exceptionally good soil, at the rate of 40 holes per hour, that is, "one hole and a move of the machine 150 feet in 1½ minutes." All crews were out for records, trying to tread on one another's heels. Three wire crews, stringing four wires, in one day covered 52.8 miles. Seventy-five transpositions had to be made in the wires. The weather conditions vere very severe, the rainfall was the greatest ever known in that section, converting deserts and flats into lakes and swamps. Poles had to be

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hauled, and set in the water. In other places it was difficult to get water at all. In the mountains snow obstructed the work, roads had to be built and repaired under great difficulties. In some places quick-sand was encountered, so that in one case it was even expected that it would be necessary to shoot the horses and abandon the outfit. Great difficulty was experienced in transporting supplies, but the work was well organized.

Now the line is finished although I have mentioned only a few of the problems encountered. I will not attempt any eloquence, as that would only be to repeat the excellent work of writers whose productions you have read, but I will pass before you some of the men who are the leaders in the work. Mr. Bell has been described as a young and little-known professor of vocal physiology. The knowledge incident to this science was of material assistance to him in the development of telephony. This might be noted as an encouragement toward branching out from our special lines of work. Mr. Thomas A. Watson was Bell's right-hand man in the early days. Theodore N. Vail is the financier of the line and president of the Bell System. John J. Carty is chief engineer of The American Telephone and Telegraph Company, in charge of the electrical and development work for the line as well as for the entire system. There are many other men who have helped in this work. The transcontinental line is possible because each one of the thousands of men has done his own work well.

During the course of his remarks, Mr. Patterson showed many interesting and instructive slides, which showed very clearly the points he wished to bring out.

Professor Willard J. Fisher, of New Hampshire State College, then delivered an address on

Methods of Projecting Lecture Experiments.

In exhibiting lecture experiments before a class, it is necessary to make sure that all members of the class may see clearly the details of the work, or of the apparatus. For this purpose sufficient illumination must always be insured, and frequently also, magnification. The latter is more important in large rooms.

The method of shadow projection with the d. c. arc lamp, shaded with a proper hood, insures brilliant illumination of the apparatus; while the smallness of the crater causes it to cast shadows of great sharpness, even with large magnification. Also, it enables certain phenomena due to small differences in refractive index of air, etc., to be made very distinct on a screen or white wall.

The following experiments were shown, to illustrate this method of shadow projection:

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The issuance of gas from an unignited Bunsen burner; the sudden expansion of the gas as it reaches the Bunsen flame; the tangential motion and the central draft of air about a rapidly whirling cardboard disk; the reaction of heated air about a whirligig driven by a draft above a tin chimney with a Bunsen inside; the discharge from a charged point into a Bunsen flame (described only); the fact that two very different catenaries are similar curves; iron filings attracted through paper and not through sheet iron; cracks in a nickel crucible; also the arc lamp and a cheap bull's-eye condenser were used to project the image of electroscope leaves, and it was mentioned that the arc gases are also a very excellent means of discharging charged bodies in electrostatic experiments. Finally, arc light passing through a sodium Bunsen flame through the slit of a spectroscope gave the reversal of the sodium lines.

After the meeting the party divided to inspect the school at leisure. Opportunity was given to visit the power plant, which supplies steam, power and electricity to the school, which is thus independent of outside sources; the athletic field of many acres, with its many tennis courts, baseball diamonds and track; the canoe pond; and last but not least the chapel, of which the school may well be proud.

Altogether the meeting was a most successful one, and many thanks are hereby extended to our hosts of the day for their efforts in making our visit one to be remembered.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SEVENTY-SECOND
REGULAR MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, December 4, 1915

at the Billerica Shops of the Boston & Maine Railroad.

10.15 A.M. Meeting of the Executive Committee.

10.30 A.M. Business Session.
Reports of Standing Committees.
Election of New Members.

11.00 A.M. Address, "The Billerica Shops." Mr. C. D. Smith, Mechanical Engineer.

11.30 A.M. Tour of Inspection of the Shops.

12.30 P.M. Lunch.

1.30 P.M. Address, "Elementary Science." Mr. J. Richard Lunt, English High School, Boston, Mass.

2.15 P.M. Annual Address of the Vice-President. "Two Needs of Today in Preparatory Physics." Mr. Frederick E. Sears, St. Paul's School, Concord, N. H.

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MORNING SESSION.

Arriving at the shops by special train from the main line, the party was turned over at once to the charge of Mr. Henry Bartlett, Chief Engineer of the Boston and Maine Railroad, whose guests the members of the Association were for the day. Mr. Bartlett introduced Mr. C. B. Smith, who spent a few minutes in giving some statistics about the shops, and in briefly describing the course to be taken through the shops. Among many interesting facts given are the following:—

The shops are for the repair of locomotives, passenger cars, baggage, milk and horse cars. They were built at a cost of $2,500,000, taking three years in the building, from the time the land-clearing was done. Completed in February, 1914, they have been in operation a little over a year and a half. At present they are not working at maximum capacity. The locomotive output could be made 33% larger, and the passenger car output 100% larger. The present output is 35 locomotives a month, and 125 passenger cars. There are 20 locomotives being repaired at one time, as well as 60 passenger cars. There are 875 employees in the locomotive, and 300 employees in the passenger car departments. The weekly payroll is $10,000, the men living for the most part in Lowell, and coming down free every morning on a special 10-car train.

The town water supply is used generally. There is a fire system, with fire drills, and automatic sprinklers throughout. A special steam jet system is furnished for fire in the oil storage rooms.

The heating system is hot water direct, forced through radiators from the power house.

The lighting system is by arc lights in the yards, and incandescent A. C. lamps in the shops.

Turbines (Curtis horizontal) are used for power, as well as Rice-Sargent engines. Motors are of both D. C. and A. C. type, both direct and belt drive. For variable speed machines, D. C. motors are used. There are motor generator sets in the power house. An extra supply of water is obtained from artesian wells, which furnish 10,000 gallons per minute.

Crude oil is used for some of the furnaces and for heating iron and steel. The oil is stored in two underground tanks, from which it is pumped. In case of fire it will return to the tanks by gravity.

The sewerage system behind the shops consists of evaporation ponds, into which the sewage is pumped.

Among operations of particular interest were the following:

The removal of tires from locomotive wheels by means of kero-

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sene vapor blasts, five in number, directed upon the periphery. It takes about 15 minutes to expand the tire sufficiently to allow of its being driven off with sledge hammers.

Cranes capable of lifting a locomotive.

Electric welding.

Hydraulic press for driving axles into driving wheels.

Hydraulic press for lifting the corners of passenger cars from the trucks.

Quickly adjustable stands, for allowing workmen to raise or lower themselves at will while painting the outside of cars. Bits for boring square holes (square hole mortiser).

Cooling pond, where condenser water is cooled by the spraying method (looked like fountains).

Oil immersed mercury arc rectifiers.

Automatic stokers in furnaces.

Overhead piping system throughout the works, inside and outside the shops.

U-shape bend in long pipes to allow for expansion. (Does away with expansion joint.)

The time devoted to the tour of inspection was altogether too short for those present to see all they desired, as there were many things of intense interest, on which many minutes might be profitably spent. The party of thirty was divided into four groups, in charge respectively of Mr. Bartlett, Mr. Smith, Mr. Norwell, assistant shop superintendent, and Mr. W. W. Brown, foreman of the machine shop.

Following is a list of the things seen in the shops:

OFFICE.—Drawing room, vault and general shop offices.

STOREHOUSE.—Storehouse scales, fine goods room, general stock room, covered stock platform, stationery department, stores accounts and telephone exchange.

LOCOMOTIVE SHOP.—Driving axle work, tire house and gantry crane, driving wheel lathes, unwheeling pit, steam pipe works, general erecting shop, lye vat house, stripping sheds, tender carpenters' work room, tender work, tank work, locomotive firing up and testing, storage for locomotive tubes and boiler plate.

BOILER SHOP.—Staybolt breaker and crane, flange fire, flange furnace, ashpan work, flue work, flue rattler, frame slotter and boring mill, cylinder and frames, electric welding work,

LOCOMOTIVE MACHINE SHOP.—Planer for main rod strap, tool room and heat-treating work, tool and cutter grinders, vertical miller on rods, slab miller on rods, planer section, portable lathe, guide grinder, milling shoes and wedges, draw cut shaper, milling eccentrics, tire boring wheel work, driving box planer, wash room, paint department, 1½ ton mono-rail hoist and scuttle, turret lathes, cab work, manufacturing tool room, sheet iron work, lubricators, small valve storage, brass room, brass turrets, tool carriers, gauge testing, chest of

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drawers for special tools, air pump work, belt repairs, air brake pipers' work, manufacturing bushings, beltman's despatch board, time recorders and general foreman's office, double end rod borer, rod job, vertical miller on rod boxes, power press, piston rod and valve stem packing, Bullard mill on by-pass valves, piston job, first aid room, link job—radius grinder, driving box job and press, Lucas mill boring driving boxes, locker room.

LOCOMOTIVE BLACKSMITH SHOP.—Case hardening, fuel oil, brass furnace, 4500-pd. steam hammer and furnace, radius crane, nazel electric pneumatic hammer, coal gantry, reclaiming bolts, forging machines, staybolt machine, taper bolt machine, iron shed and shears, scrap dock, gantry crane, conveyors, cooling pond.

POWER HOUSE.—D. C. generator unit, air compressors, gauge boards, exciters and night unit, turbine engine, Rice-Sargent engines, switchboard, mercury rectifiers, turbine auxiliaries, hot water heating system and turbine pumps, pipe duct, boiler auxiliaries, ash pit, fire pumps, coaling system, stoker fired boilers.

CAR PAINT SHOP.—Door and sash work, wash tracks, general car painting, car testing and finishing, paint and oil storage—Vowser system lumber shed and dry kiln, stock room, lacquer work, lacquer baking room, nickel plating, car cushion cleaning, drying room, hair-picking room, upholstering room, pressure cleaning cushions, transfer table, mill room, coach repair shop, elevator, cab work, special stock, pattern work, cabinet work, tin work.

CAR BLACKSMITH SHOP.—Reheating tank for hot water system, forging machine, bulldozer.

CAR MACHINE SHOP.—Iron sheds, car wheel lathe, wheel presses and axle lathe, car wheel borer, air brake test rack, tool room and pipe work, wheel and axle storage.

AFTERNOON SESSION.

The business session, postponed from the morning, to allow as much time as possible for the shops, opened with Mr. Hall in the chair.

On recommendation of the Executive Committee, the following were unanimously elected to associate membership:

Mr. Andrew T. Aldren, Newton Technical High School, Newtonville, Mass.

Mr. John W. Dow, Central High School, Springfield, Mass.

Mr. Harry N. McLaren, High School, Manchester, N. H.

Mr. W. S. C. Russell, Cambridge Botanical Supply Company, Waverley, Mass.

Mr. William E. Smith, English High School, Boston, Mass.

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On recommendation of the Executive Committee, Mr. A. B. Warren of the Mechanic Arts High School of Boston was changed from associate to active membership.

Following is the report of the

COMMITTEE ON NEW APPARATUS,
Mr. R. C. Lowell, *Chairman.*

Mr. Hall showed a periscope model of wood about 2 feet long and 2 inches square. This is put out by the Cambridge Botanical Supply Company at $2.50.

Mr. Lowell showed several new pieces of L. E. Knott apparatus, including a working glass model of a lifting pump. This must be turned upside down to show the valves. The number is 35-50 and lists for $6.85. It fits to the universal table clamp.

A working glass model of a water turbine, No. 37-20, to sell for $4.50.

The Packard porcelain electrolytic apparatus base.

Mr. Lowell called attention to a hydraulic press of Mr. J. C. Packard, consisting of an old bicycle pump, with a board secured perpendicularly to the handle. By connecting this through vacuum tubing with a small bicycle pump, a good-sized boy can be lifted.

Following is the report of the

COMMITTEE ON CURRENT EVENTS.
Mr. R. C. Chittenden, *Chairman.*

A phonometer invented by Dr. A. G. Webster of Clark University, not only measures the intensity of a sound, but also tells within a very few degrees the exact direction from which the sound comes. The instrument has the appearance of a surveyor's transit with two horns projecting at one end. The sound enters the horns, impinges upon a delicate diaphragm which moves a needle attached to it. The needle in turn moves a mirror which reflects light from a small electric bulb which is observed through a lens at the other end of the instrument. When the sound is loudest the light is highest and the direction of the sound is at right angles to the horns.

Professor Pupin claims an invention which will revolutionize the wireless business. The instrument consists of a receiver which is sensitive only to such waves as the operator desires.

In North Dakota is a wind mill used to run a generator, light a whole farm and charge a storage battery.

Disturber IV, a 40-ft. hydroplane, recently covered, at Chicago, a half mile course at a speed of 62 miles per hour. It has two 12-cylinder motors and develops 1800 H.P.

Prof. M. M. Wood of Chicago describes some uses of violet rays in time of war. A tuned herzon ring, with the gap stopped with gun-cotton, could be concealed in a lump of coal, for instance, and hidden

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on one of the enemies' ships. An operator on shore could fire the gun-cotton and destroy the ship by tuning his wireless to the proper wave, or by bringing the ring and the violet ray into focus. The U.S. Naval advisory board is in possession of the secret, and it will soon be possible to fire turret guns by use of violet rays.

A catapult, or device for launching aeroplanes from the deck of a vessel, was tested early in November at Pensacola. Tracks were laid on the after-deck of the cruiser *North Carolina*, upon which runs a car. An aeroplane can land on the car and be secured. The car is then driven down the track at high speed, stopping at the end, and shooting the aeroplane over the stern at a speed of 50 miles per hour.

Louis Rota, an Italian engineer, has invented an apparatus which, by the action of electric currents, can be elevated to a height of 3000 feet and held motionless, or driven in any direction at a speed of over 100 miles per hour. The apparatus is spindle shaped, 12 ft. long, 2 ft. in diameter, and can carry a weight of 90 lbs. The invention is based on reactions obtained from the electro-magnetic forces of the atmosphere.

Dr. H. B. Cox has demonstrated in New York a wireless telegraph device which may be strapped about the waist and hidden under a coat. A cane serves for antennae. It has a range of 18 miles. The outfit includes 5 dry cells and a vibrator, and takes half a watt. Similar devices for wireless telephony are in use in the French army.

Prof. T. J. J. Lee, an astronomer of Montgomery, Mo., says: "Gravitation is an electrical phenomenon and does not act instantly across space, but is transmitted with the velocity of light." He contends that gravity is due to elementary currents of electricity circulating around atoms of matter. As more of these atomic currents, in respect to the two bodies, flow in the same direction than in the opposite direction, there is always attraction between all bodies, though feeble compared to magnetic attraction. This is an extension of the law discovered by Ampere in 1820, that two parallel currents of electricity, flowing in the same direction, attract one another.

The U. S. submarine F-4, sunk in the early spring off Honolulu in 300 feet of water, was brought to the surface the last of August. Six large cylindrical pontoons were built, sunk around it and made fast. Then air was forced into them and the boat slowly brought to the surface.

Dr. William W. Christmas, of Washington, D. C., has orders from the allies for 11 aeroplanes several times the size of the ordinary machines and costing $100,000 apiece. These machines are built with cantilever trusses, which will support much heavier weights than the usual parallel truss. The length over all is 104 ft. and the wing span 180 ft. They will carry 6 guns and an equipment of over 25 bombs, 14 inches in diameter and 5½ ft. long. The crew of 6 or 8 men is amply protected by armor, and each of the two pilots, in

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separate compartments, has two sets of controls. The motor will develop 1600 H.P.

English makers have developed a steel especially adapted for cutlery, which is said to be non-rusting, unstainable and untarnishable.

About the middle of October, naval officials at Arlington, Va., succeeded in transmitting wireless telephone messages to Honolulu, a distance of 4600 miles, and to the Eifel tower in Paris.

The world's largest single-unit turbine is at the Waterside Station of the New York Edison Company. It is 57 ft. long, 20 ft. wide and 14 ft. high. Weighing 975,000 lbs., it develops 40,000 H.P. It makes 1500 r.p.m. and is almost noiseless.

Owen Magnetic: "The car of a thousand speeds." This new principle of auto construction just jumping into prominence, consists essentially of a 6-cylinder gasolene engine, a generator and a motor. The generator field coils are part of the engine crank and revolve with it. The two armatures are keyed to the propeller shaft, while the motor field is stationary. The gasolene engine is controlled in the usual way and the generator by a third lever on the wheel. At high speed the generator armature is magnetically locked with the field and revolves with it. On climbing a steep hill the controller lever is moved back from "high," letting the generator "slip," thereby generating a current which is led to the motor, which then acts as a power booster on the propeller shaft. There are no gears to shift and no levers.

Following is the report of the

COMMITTEE ON MAGAZINE LITERATURE.

Scientific American. February 6, 1915. "Across the Continent by Telephone."

February 13. "Onnes, the Dutch Specialist in Cold." "Work on the Caleveras Reservoir of the San Francisco Water Supply."

March 27. "Principles of Radio-Telephony." "The Superheated Steam Unit. Economic Steam Engine." "An Aerial Monorail."

April 10. "Color Music."

April 17. "Measuring One Twenty-Millionth of an Inch."

April 24. "Saving Eight Million Tons of Coal a Year." "A Hydro-Electric Development that Uses a Head of 4000 Feet."

May 15. "What Matter Is Made Of. Resemblance of the Atomic Structure to an Infinitely Small Solar System."

May 29. "A Mercury Vapor Engine."

June 5. "Seventy Years of Invention. This Issue Is the Seventieth Anniversary Number. Many Interesting Cuts."

June 19. "Running Railroads by Water Power. The Senseless Waste of Money in Buying Coal Where Ample Water Power Is Available."

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August 21. "A Ten Thousand Horse-Power Water Turbine."
September 4. "The Hell Gate Bridge."
September 18. "America's Greatest Irrigation Project. Southern Alberta."
October 9. "Arlington to Honolulu by Wireless Telephone." "Boat Design that Eliminates Wakes and Bow Waves."
October 16. "Submarines Betrayed by Sound Waves." "The Hell Gate Arch." "The Arrowrock Dam."
November 6. "Three Thousand Volt Direct Current Electric Locomotive."
November 16. "Microscopic Study of the Phonograph."
November 20. "Efficiency in the Household." "Providing a Ship with Ears."
Scientific American Supplement. February 6, 1915. "Causes of Solar Heat."
February 27. "Oxy-Acetelene Welding."
March 6. "A Means of Investigating the Interior of the Earth by Electric Waves and Oscillations."
March 13. "Relation of the Horse Power to the Kilowatt."
April 24. "Wireless Transmission of Energy."
May 1 to June 5. "An Article on Atoms and Ions," by J. J. Thompson, in Six Parts.
June 12. "Electrification of the Norfolk and Western Railway." "The Time System of the United States." "Gyroscopic Phenomena."
August 7. "Search Lights and the Visibility of Distant Objects."
August 14. "Construction of a Vibrating Rectifier."
August 21. "Conductivity of Metals. A New Theory of the Passage of Electricity Through Metals."
September 4. "Pyrometers for Shop Use."
September 18. "Theory of Cold Light."
September 25. "Manufacture of Liquid Air."
October 16. "Uses of Intense Heat." "Atoms, Molecules and Electrons. A Very Good Popular Exposition."
October 23. "Solar Radiation." "Principles of the Periscope Construction."
October 30. "Utilization of Exhaust Steam." "The Trend of Electrical Development."
November 13. "Thermal Insulation."
November 20. "Contact Electrification and the Electric Current."
November 27. "Electric Locomotive."
School Science and Mathematics. March, 1915. "Bridges as Illustrative Material on the Parallelogram of Forces." Harvey N. Davis. "The Present Status of General Science."
April. "Notes on Notebooks."
June. "Water Barometer." John C. Packard.
November. "Grimsehl's Laboratory." N. Henry Black. "A Laboratory Review."

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Mr. John R. Lunt of the Boys' English High School, Boston, then delivered an address on

Elementary Science.

The course in Elementary Science at the English High School of Boston was organized under the supervision of Mr. Samuel F. Towner, head of the Science Department. The content is the result of his valuable suggestions. The method of presentation is essentially his—the method he has employed for many years in his own teaching.

When, four years ago, the organization of the course was begun, no text-books could be found which fulfilled the requirements. All the Elementary Science books which we examined seemed to be a combination of physics, chemistry, biology and physiography, in a dilute form, too superficial in content and artificial in treatment, to meet the needs of our first year boys. In consequence it became necessary to organize a course along the lines of our own ideals. In accordance with the project method, formulated by Prof. John F. Woodhull of Columbia University, selection was made of definite experiences from the environment of the boy.

Many projects have been tried, but the present course includes only Weather, Water, Combustion, Illuminating Gas, Electric Lighting and Bacteria. The development of these projects has been a slow and difficult task. It has involved the unfailing and earnest coöperation of the Weather Bureau, Water Works Department, City Engineers, the Boston Consolidated Gas Company, Edison Electric Company and the Board of Health. It has involved many visits to the home and a continuous study of home environments. It has involved ceaseless observation and analysis of the mental processes of the boy.

Space would not permit a detailed description of the development of each project. The nature of the content may be illustrated by the study of combustion. This project involves the study of fuels, the kitchen stove, the draught, slow burning, rapid burning, the fire, flames, ash, smoke, what becomes of the fuel, how heat travels, how the kitchen is warmed, furnaces, hot water heating, steam heating, and a study of the school heating plant.

The whole project, from the start to its final comprehension, is a growth, from simple to more complex; the interpretation of each successive experience depending on previous experiments. The boy performs the preliminary work at home. He holds a smoking stick before the ash door slide of the stove. He builds a fire. He makes it burn fast or slow. He operates the furnace, shovels coal, sifts ashes, and performs many other tasks. These preliminary operations are necessary before an attempt is made to interpret the experience in the class room. The lesson begins with an appeal to the boy to tell what he did, what he observed and what happened. An opportunity is then given him to explain the fundamental principles

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involved,—to tell *why* it happened. The next step is the reproduction of the experience as near as possible in the laboratory. The boy makes a fire burn fast or slow before the class. Observations are given, and an attempt is made to discover the fundamental principles. Thus the boy is led to reason for himself the laws underlying his experience.

The laboratory experiment, supplemented by home observations, makes possible a dramatic presentation of ideas, bound to secure universal enthusiasm and mental effort. The boy is the scientist. He wrests from his own experiences the laws and principles which govern them.

The effect on the boy is remarkable. At the beginning of the year whole classes of boys are easily led to admit, after opportunity for deliberate judgment is given them, that a rubber hose is made of lead, that a decidedly crooked line is straight, that pine wood is heavier than iron, or that water will run up hill. These are only a few of the astounding absurdities which characterize the boy's observation and reasoning. The progress of the course marks decided changes. He observes accurately and closely. His reasoning power and scientific attitude develop to a remarkable degree. His deductions are often little short of marvelous. He acquires an individuality of thought and conviction of belief that cannot be shaken.

The development of this scientific attitude of mind is the chief aim of the course. In these critical times when the welfare of individuals, families, cities and nations depends so much upon sound judgment and sane action; in this age of evil temptations, unclean homes, political corruption, false ideals and superficial finery, no training is more essential for the coming generation than that which will help to develop the scientific attitude of mind: the power to observe minutely, to analyze keenly and to synthesize constructively. With this aim science teaching becomes a glorious opportunity for usefulness, before which the mere acquisition of second-hand facts from a text-book pales into insignificance

The progressive method of science teaching by reasoning from experience insures proper articulation. In fact there is no articulation. The experience and its principle are never separated. It is a natural growing process. It is the process by which we acquire in life our most useful and lasting knowledge. The method is humanitarian. It leads to a higher appreciation of and a keener interest in the environment. The commonplace repetition and monotony of everyday life is given a meaning and stimulating significance.

This method of science teaching assumes a social value in striving to elevate standards of living. Many of our boys come from the poorer tenement house districts of the city. He often lives in two or three dark rooms facing a brick wall or back alley. According to statistics of the Board of Health, we find that tuberculosis and other contagious diseases are most prevalent in these parts of the city.

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The boy is led to tell about these conditions of his environment. Then he seeks the reason why. He inoculates a tube of melted agar with bacteria from cultures. He pours this into a Petri dish, and covers it with black paper. A round hole is cut in the paper. This is placed in the sun for about forty-eight hours. At the expiration of this time the boy removes the paper He sees countless colonies of organisms in the agar, forming a circle around the dish, but under the hole the agar is clear; no trace of bacteria can be seen. As a result of these observations the boy reasons that the direct rays of the sun destroy bacteria or inhibit their growth. He then reverts back to his environment. The darkness of the tenement fosters the growth and multiplication of pathogenic organisms. One of the fundamental and vital problems of the boy's environment is thus revealed to him. He denounces these conditions. He expresses his determination to change them. He is transformed into a worker for social betterment among his own people.

No more convincing evidence of the value of this scientific reasoning from experience can be secured than through the attitude of the class. Interest soon becomes enthusiasm. The boy rises and stands voluntarily. He is alert and earnest. He is eager to describe his observations or relate his experiences. He strives with all his energy of thought and mind for the great hidden truth. During the experiment he wants to crowd around the desk. He is hushed with wonder and awe, or he is inspired to violent demonstration of his zeal. A firm guidance must be exercised at all times lest he shout or rush in wild confusion about his instructor or experiment table. No observation of discovery is repeated by the teacher. Slowly and constructively the experiment develops to the conclusion; often the great fundamental principle is deduced and formulated with a simplicity of expression and degree of accuracy far superior to the wordy formula of the text-book. In his own naive, natural way, the boy expresses the truth—the truth he has discovered. To him it is a new revelation. The principle is his—not Archimedes.' It did not come down to him from past ages. It is modern history. With proper guidance and stimulation the boy can thus interpret the full meaning of the experiences of his environment. He will grasp about all that is worth while. He will reason out for himself the great laws of weather, the problems of water supply, the principles of combustion, and the causes of disease contagion.

Each experiment is carefully written up by the boy. Here, too, his interest is evident. He often spends hours of painstaking toil on elaborate sketches or detailed description. This part of his task is constructive. The boy does not write a paper for the teacher's criticism. He is writing a science book for himself. The papers are returned at the end of each project. The boy arranges these papers, makes an index, and binds them together in the form of a pamphlet. This he is allowed to keep as a permanent record of his own achievements.

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We have, furthermore, many testimonials from our boys of the practical application of these discoveries to home conditions. Bad plumbing is corrected, leaks are mended, meter bills are checked, stove flues are cleaned out, coal is purchased by the ton instead of by the bag, gas stove burners are cleaned, Welsbach burners are substituted for open burners, Tungsten lamps for carbon lamps, back alleys are cleaned, garbage is properly disposed of, tooth brushes are purchased, and sunlight is let into the home. These are a few of the many changes reported again and again by the boy.

So far as content is concerned, the course is entirely experimental. Many things have been tried and discarded. Undoubtedly more things will suffer the same fate. We study nothing but what is part of the boy's natural environment.

Our particular aim has been to teach the boy that the text-book and the teacher's word are not the final authority in matters of science, but that the important thing is for him to use all his senses in making observations and common sense reasoning in drawing logical conclusions.

Mr. Frederick E. Sears of St. Paul's School then delivered the Vice-President's Annual Address, his subject being,

TWO NEEDS OF TODAY IN PREPARATORY PHYSICS.

Physics as a secondary school subject, whether given as preparation for college or not, suffers more today because of its innumerable attractions and wealth of material than from all other elements combined. This endless supply of interesting material is the source perhaps of most of the difficulties with, and disagreements about, elementary physics courses. These courses often are very broad, but have certainly become very thin. Secondary school physics has plenty of extent but no great depth.

Now this absence of depth, this lack of thoroughness, existing though it does, is not due at all to any slackness of mind or absence of thought, but is due to the natural desire on the part of interested teachers to give to their pupils as much as possible from a flood of material, and to an equally natural feeling on the part of the pupil that he is entitled to it.

The only possible remedy for this unusual condition in preparatory physics work today is more time. Additional time can be obtained either positively or negatively. If positively, there are two ways that may be suggested. The first is simply to add a certain number of hours a week to the school schedule for physics instruction, perhaps even double the present amount of time, and to ask the college entrance boards to count preparatory physics 1½ or 2 points instead of 1 point. The possibility of accomplishing this seems, however, most remote, though it would be the ideal way if it could be done.

The second positive way would be to remove some of the excres-

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cences now attached to physics courses. Here there seems to be more hope, and by this method much could be accomplished in the way of securing more time for the teaching of true physics.

Undoubtedly the time will come when physics, with all that it now includes, will be sub-divided, leaving the parent subject, physics, but with several off-shoots known by different names. This is as it should be, for much is taught today under the general name of physics that should be taught in separate courses under other names. This tendency toward subdivision is also natural, for when a school or an organization, or a subject for instruction, becomes unwieldy, it should be subdivided into smaller groups for more efficient handling.

In fact, such sub-division is perhaps beginning. Even general science courses, so much in vogue, at least save time for the later course in physics by teaching the most elementary parts of the subject in the earlier years. Other and more complete subdivisions will, let us hope, soon take place. Vocational science as a separate subject might relieve physics almost entirely of its burden. The point is that physics has more than kept pace with the general increase in scientific knowledge in the last half century. As has been often said, our fathers learned in college in a course or two all the science of their time. So rapid has been the increase in the latter years that many of us have forgotten that there is such a subject as pure physics in our endeavors to absorb into our physics courses each and every practical application of physical principles.

Now I am not in the slightest degree a believer in making physics a theoretical subject, but neither do I think it is possible within our limited time to do decent work and at the same time absorb into our courses everything remotely connected with physics. Most of these things are wonderfully interesting and extremely useful, but their place is in other new courses,—courses which, for many pupils, are much more valuable than merely a physics course.

To secure time negatively for more thorough work, means, of course, to reduce the number of things taught.

Just as with possessions, a few things of good design and fine material, made to endure, are more useful and give more complete satisfaction than many things of the baser sort, so a small number of physical subjects, basic in principle, thoroughly absorbed, would be of far more advantage and far more satisfactory than a little information about many things.

Two ways are open along this line. One, the way so often discussed, of leaving out of the course some whole subject, such as "Light" or "Sound." There are few who favor this, and the reasons against it will not be repeated here.

The other way is to make an effort to restrain the desire to place before a pupil in 120 hours all that physics has to offer, but to make sure that the principles which are valuable for his future are firmly

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fixed in his mind and thoroughly understood. For, after all, a first course in any subject cannot and should not do more than lay the foundations broad and deep for future work.

Certain objections to this plan immediately spring to mind, but as there are always obvious objections to any plan the question must ever be, whether the gain is greater than the loss.

Now to simply remove from a physics course a considerable amount of interesting and valuable material is unquestionably an unpopular thing to suggest, no matter how right or how necessary. If, however, a plan could be devised by which some element of special enthusiasm and interest were retained and at the same time real thoroughness in all parts of the subject striven for, might not such a plan help the problem?

The following suggestion is made, and even though it have no element of originality, yet I would just as earnestly urge it for consideration.

The main suggestion is that each pupil select, under the direction of his instructor, a certain part of the whole year's work which he shall study in some detail and with considerable care and thought. Just how great a portion of the work this should be is a matter for debate, but it should not be too large a part or the end aimed at would be defeated. For a given year the selected part could be the same for all pupils of a given school if the teacher thought best, though this would not seem as desirable as to have several different subjects for special study by different pupils.

The advantages of such a plan are several. That enthusiasm for, and knowledge of, some particular subject in physics which a pupil may already possess, would be secured, or else an interest in some definite subject developed, with the resulting satisfaction that comes from knowing one thing really well.

Laboratory experiments of a less elementary nature could be used and a better appreciation of scientific instruments and methods developed. And above all, real thoroughness might be secured within the present time limits.

The corollary to the main suggestion is that the rest of the work should, as has been indicated before, be a thorough mastery of those important principles which are the basis of the common future needs of all pupils.

This does not mean drill in mathematical problems more than it means much interesting and descriptive work and many practical illustrations. It means both, each as far as the limited time will permit, to the end that a well balanced course may result.

Now naturally such a plan would mean a modification of the present college examination to the extent that questions designed to test the candidate's knowledge of his special subject would have to be introduced. This could be done by having one question, of considerable length and several parts, in each of the five groups of the

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College Entrance Board, for example. Each candidate would then take one such question from the whole paper and would take no other question from that group.

I believe that such a paper, based on some such requirement, would do much to solve some of our present disagreements and difficulties.

Quite surely human nature derives the greatest enjoyment and satisfaction from things with which it is most familiar.

It is quite natural, therefore, for the teacher who has a real liking for his work to feel that knowledge of his chosen subject is of far more value to the human race than knowledge of any other subject. Among the sciences, physics has certain claims for unusual value, which the teacher of physics believes entitles it to first place. If a subject to be valuable educationally must have in it elements which will train the observation, develop the reasoning powers, stir the imagination, place natural beauties before the mind, then physics deserves a very high place.

But of all these, the most important just now is reasoning power. Whether right or not, I firmly believe that physics has in it this element to as large an extent as any subject, and to a far greater degree than most. Information and knowledge are today and always will be necessary and valuable, but a clear reasoning mind is more essential still.

In these trying days more than ever before, and still more in the terribly trying years that lie ahead, a well reasoning mind will be needful; not alone a mind that has a fair amount of information or knowledge, but a mind which using that knowledge for accurate reasoning, can keep its straight course amid all the befogging words thrown out to confuse.

For years, schools and school men have said that training a boy's character was the most important part of education. It has been a perfunctory statement and attempted in a perfunctory manner. A man's character is not what he knows, it is not even what he does, but is what he thinks. "As a man thinketh so is he," and as a matter of fact the ordinarily decent man acts as he thinks. Here is an opportunity, at least, to redeem that statement about training a boy's character in our schools. Now and for a long time to come our young men and young women will be going through the world's greatest crisis. Today the thoughtful man knows that the immediate years will begin a new era in this country, one which will be an era of wonderful development, or one which will mark the beginning of national disintegration. And the thoughtful man knows that only the mightiest efforts on the part of the right thinking men and women will save us from error. Right thinking does not mean well intentioned thinking. Right thinking cannot come by desire alone. Right thinking, straight thinking, can come only from a rightly trained mind. We need, therefore, as many minds as possible among the well intentioned which are capable of clear thinking; minds

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which cannot be deceived by false statements or specious arguments; minds which cannot be deluded by false prophets or quieted by a smooth tongue; minds which having been trained to follow unflinchingly a correct principle, no matter wither it may lead, must by necessity arrive at the right goal.

Every teacher of every subject might well think for a while only of one thing, and that, how he can best aid each pupil to think straight in the future years about all the problems that will confront this land. But surely the teachers of history and of physics have the largest opportunity and the greatest responsibility. In history, there is the double responsibility of not only providing the historical data of the past for guidance for the future, but also of training the mind to clear reasoning about natural causes and human motives. In physics, there is the double opportunity of supplying not only skill and knowledge, but of developing clear thinking to a high degree.

If this is true, if physics is a subject unusually suited to training the mind, we should do what we may. We should use the particular instrument placed in our hands to help fashion minds that will be able to distinguish unerringly between wisdom and folly.

For most certainly, as our youth of today think and act in the approaching years, so will our country's future be decided.

It is not vain imagining which believes that it is not entirely technical skill which we need, but sound judgment; not alone a full mind, but a discerning one.

The Saturday meeting then ended with a rising vote of thanks to the speakers of the day, and to the officials of the Boston and Maine Railroad for the cordial reception given the Association, and for the most excellent guidance and many efforts to make the day one long to be remembered.

SMOKER AT CITY CLUB, FRIDAY EVENING, DECEMBER 3.

At the Smoker there were thirty-five members present. Addresses were delivered by Professor Edwin H. Hall, Dr. C. Ribourg Mann, and Professor John F. Woodhull, who took as the topic of discussion,

College Recognition of Applied Science.

Following is the address of Professor Hall:—

Mr. President and Gentlemen:

When I was first invited to engage in the discussion of this evening, the subject for debate was given as "Collegiate Recognition of Vocational Science." Taking *recognition* to mean *acceptance as part of admission requirements*, and taking *vocational science* to mean, for example, stenography or carpentry, I had no hesitation in saying that I had an opinion to express,—and most of you will not be sur-

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prised to hear that this opinion was unfavorable to the proposition as I understood it.

But when the printed call for this meeting came, I found the topic in question to be "Collegiate Recognition of Applied Science." About the same time my eye happened to fall upon the full title of the particular professorship to which, very much to my surprise, I was appointed a year or two ago. I am, I find, *Rumford Professor and Lecturer on the Application of Science to the Useful Arts.*

The two little discoveries which I have just noted, the title of the subject for debate and the title of my academic position, have made what may fairly be called a dramatic change in the circumstances of my personal enagagement in this discussion. I may compare myself to one who, going out to shoot at what seems to be an easy mark, suddenly finds himself in ambush and obliged to defend himself, surrender, or be slaughtered. I shall try to do the first of these three things.

I recall certain pregnant sayings of other men which are helpful to me in this emergency. The first and the greatest of these is, "*Man shall not live by bread alone.*" Bread is a prime necessity of man's existence, and is recognized as such in the proposition just quoted. The same great teacher who uttered these words taught men to pray reverently for this daily bread. No one, then, should be ashamed who in good honest fashion helps in any capacity to provide us with this daily bread,—that is, with any one of the prime necessities of our existence on this earth. Anyone who does this has a right to hold up his head in any company; "he shall stand before kings." Longfellow has celebrated the village blacksmith; Carlyle was proud of his own father as a stone mason who did good and honest work. Christ himself, according to tradition, grew up as a carpenter; but he saw with the utmost clearness, and in the declaration "*Man shall not live by bread alone,*" he uttered with the weightiest authority, this fact, that the nobler part of man, man as distinguished from the animal, cannot be sustained on the mere necessities of comfortable existence. In perfect accordance with this teaching the early settlers of New England, as soon as their bodies were barely provided for, began to build colleges,—not for the purpose of teaching any handicraft, or even agriculture, but for the training of young men to be guides to their minds and lights to their souls.

But, you may say, all this was a long time ago. When one looks at these same colleges today, he sees most conspicuous, not a company of godly youth preparing for the ministry, but a crowd of fifty thousand people rushing to a football game, where the modern successors of the godly youth handle each other with unchristian roughness. The superficial or unsympathetic observer of college activities in these times will very naturally say: "The old spiritual leadership, the old spiritual function is gone forever; let us at least

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try to make the colleges effective in a utilitarian way, since they have ceased to be effective in a higher way."

But just here, in my opinion, such a proposer would beg the question, the main question, at issue. It is true that theology has a smaller place in the minds of men, that religious observance has a smaller part in the conduct of men, in college and out, than each formerly had. But theology and religious observance rose in answer to the higher needs of our nature, and these needs remain to be served,—unless we are content to take our place henceforth with the beasts that perish, with the creatures that are content with animal comfort. An old-fashioned term for a college education was a "liberal education," and in my opinion it is still the main function of a college to give a liberal,—that is, a *liberalizing*,—education. It should broaden one's understanding of, and one's sympathy with, his fellowmen, by the study of human institutions and beliefs, past and present. It should illuminate and strengthen the mind by the study of science, and in the course of this study, reference to the practical applications of science is not only permissible, it is eminently desirable; to avoid such reference would be the opposite of liberal; but it should be incidental, illustrative, a friendly and modest look over into the territory of a neighbor,—the practical expert. For example, there are two ways of approaching the study of a heat engine. One is from the standpoint of thermodynamics, the other is from the standpoint of the mechanic or of the chauffeur. Now there are times when human life depends on moving the right lever in the right direction without an instant of conscious reflection, and at such times a knowledge of thermodynamics is not of the least use. There is great practical virtue in the automatic skill which long practice has given to the craftsman, great moral virtue in the persistent effort which has achieved this skill; but this practice and this skill should be content to remain within their own sphere of unquestioned usefulness and honor,—just as the professor of thermodynamics should be glad to leave the running of trains to the grimy and capable members of the engineers' union. I once heard Mr. Walter Page, now our Ambassador to England, but formerly editor of the *Atlantic Monthly*, express himself substantially as follows: "*Science* (of course he meant applied science) *preserves life; but literature makes it worth preserving.*" Now with literature in this function I should put the great generalizations of science itself. The two main principles of thermodynamics, for example, are, for one who has mastered them, great treasures of thought. No amount of mechanical skill could, in my opinion, take the place of these principles in giving intellectual range and intellectual satisfaction,—in fulfilling, that is to say, one of the great purposes of a college, a liberal education.

I am drawing a distinction, as you have doubtless perceived, between a college and even the highest grade of technical school. Many years ago I visited one day the steam engineering laboratory,

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then a new building, of the Massachusetts Institute of Technology. The place was so large, so busy, and so business-like, that I said jokingly to the professor in charge, "I have been visiting your mill." "That's just what it is," he replied, "a mill; and we turn out a manufactured article. Out at your place you aim to produce something that will grow." Now he had carried my thought much farther than I had taken it, and perhaps in his comparisons of our respective institutions he was not always so complimentary to Harvard College as he appeared to be in this instance. But he had expressed in a flash a real difference of ideals, which must always to some extent exist, between the institution that seeks to produce immediate effectiveness in its graduates and the institution that has a more general, a broader and perhaps necessarily a vaguer, purpose.

But, though proceeding from different standpoints, the seeker for practical utility and the seeker for breadth of view will naturally cover some common ground. Certain among us here remember the professor from an agricultural college who, addressing an audience in Boston at the last meeting here of the National Educational Association, gravely urged that the best way to engage pupils in the subject of hydrostatics is to make use of their natural and spontaneous interest in the hydrostatic or hydraulic properties of different farm soils. Now I had never before thought of that particular way of approach to this department of physics, but it would be a grave mistake on my part or on the part of any college man to ignore sound scientific knowledge merely because of the way or the place of its attainment. In fact, looking sharply at the question before us as it stands in print, we see that can only be a question of degree, of more or less; for colleges in this country have been recognizing applied science, in some sort and measure, for a long time, both in their admission requirements and in their own bodies of instruction.

If this question of degree means, as I still suppose it may mean, the inclusion of such accomplishments as stenography or carpentry in the list of studies a boy may offer in satisfaction of the entrance requirements to college, I regard the proposition as highly objectionable,—both from the standpoint of the college and from the standpoint of the vocational school. I speak as a friend of each of these institutions.

We have heard much and for many years about the tyranny of the colleges toward the schools. Now if there is such tyranny, what supports it? Does the law give the colleges dominion over the schools? Not at all. How, then, do they have and keep it? Perhaps some will say that it is by reason of their venerable age and their prestige. But mere age does not insure continued power, and prestige is merely another name for reputation and influence,—the very things we are seeking to account for. I think we shall have to admit that the colleges have influence and respect because, on the whole, they deserve influence and respect. These are precious possessions,

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and they should be cherished. I ask you, gentlemen, to consider how long they will continue if the colleges, surrendering the self-guidance that has made them and kept them strong,—too strong, some of their enemies would say,—accept control from those who rail at them and from those who would subvert their very ideals.

And now for the point of view of the vocational schools. I am heartily in favor of such schools, provided they really do what they profess to do, prepare boys and girls for the practice of certain vocations. They have succeeded, I believe, abroad; I hope most earnestly that they will succeed here. We have been leading up to them, groping our way to them, through a series of experiments,—manual training schools, mechanical art schools, etc., naturally enough only partially successful. I had hoped that the present vocational schools had got beyond the experimental stage, that they were finding themselves able to stand on their own feet and march. And so the question of this evening, if it means what I am now supposing it to mean, is to me, as a well wisher of these schools, discouraging. What is the motive, the interpretation, of the movement, if it really exists, for the recognition of vocational studies as preparation for admission to college? Merely this, that the promoters of this movement lack faith in the real success of vocational studies. It means that they propose to continue vocational schools as an experimental enterprise, and to insist that the colleges shall underwrite this enterprise by agreeing to take the product off their hands in case they should fail. Failure, as the term is here used, includes the case of the pupil who, though well taught, is unwilling to follow the vocation for which he has been trained.

Gentlemen, if the vocational schools succeed as such, the question of recognition will take care of itself. The only kind of recognition that is really worth having is the kind one does not have to ask for, the kind that comes inevitably to any honest man who does his own work well.

Following is the address of Dr. Mann:—

The problem of college recognition of applied science is one of the oldest and most important questions in American education. It is a hardy perennial that has thrived and prospered through the frosts of many a bleak New England winter.

This problem is indigenous to America, and it is important in considering it not to lose sight of this fact. It was discovered by William Penn, who, in his Fruits of Solitude, published in 1693, says: "The World. . . ought to be the *Subject* of the Education of our Youth, who, at Twenty, when they should be fit for Business, know little or nothing of it. We are in Pain to make them Scholars, but not men! To talk, rather than to know, which is true *Canting*. The first Thing obvious to Children is what is *sensible;* and that we make no part of their Rudiments. We press their Memory too soon,

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and puzzle, strain and load them with Words and Rules; to know *Grammar* and *Rhetorick* and a strange Tongue or two that it is ten to one may never be useful to them; leaving their natural *Genius* to *Mechanical* and *Physical*, or Natural Knowledge uncultivated and neglected; which would be of exceeding Use and Pleasure to them through the whole Course of their Life. Children had rather be making of *Tools* and *Instruments* of Play: Shaping, Drawing, Framing, and Building, etc., than getting some Rules and Propriety of Speech by Heart; and those also would follow with more Judgment and less Trouble and Time."

Benjamin Franklin made a noteworthy contribution to the solution of this problem in his Proposals Relating to the Education of the Youth of Pennsylvania in 1749. In this he advocates the teaching of the English Language, Arithmetic, Geometry, Astronomy and History,—"those things that are likely to be most useful and most ornamental; regard being had to the several professions for which they are intended." He thus describes his scheme for presenting this material:

"But if History be made a constant part of their reading, may not almost all kinds of useful knowledge be that way introduced to advantage, and with pleasure to the student As Geography, by reading with maps, and being required to point out the places where the greatest actions were done. Ancient Customs, religious and civil, being frequently mentioned in history, will give occasion for explaining them. Morality, by making continual observations on the causes of the rise and fall of any man's character, fortune, and power, mentioned in history. Indeed, the general natural tendency of reading good history must be, to fix in the minds of the youth deep impressions of the beauty and usefulness of virtue of all kinds, public spirit and fortitude."

"History will show the wonderful effects of oratory, in governing, turning and leading great bodies of mankind, armies, cities, nations. When the minds of youth are struck with admiration at this, then is the time to give them the principles of that art, which they will study with taste and application."

"On historical occasions, questions of right and wrong, justice and injustice, will naturally arise, and may be put to youth, which they may debate in conversation and in writing. When they ardently desire victory, they will begin to feel the want, and be sensible of the use of logic, or the art of reasoning to discover truth, and of arguing to defend it, and convince adversaries. This would be the time to acquaint them with the principles of that art."

"The history of commerce, of the invention of arts, rise of manufacture, progress of trade, change of its seats, with the reasons and causes, may also be made entertaining to youth, and will be useful to all. And this, with the accounts in other history of the prodigious force and effect of engines and machines used in war will naturally

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introduce a desire to be instructed in mechanics, and to be informed of the principles of that art by which weak men perform such wonders, labor is saved, and manufactures expedited. This will be the time to show them prints of ancient and modern machines; to explain them, and let them be copied, and to give lectures in mechanical philosophy."

"The idea of what is true merit should also be impressed on their minds, as consisting in an inclination joined with an ability, to serve mankind, one's country, friends, and family; which ability is to be acquired. . . by true learning; and should, indeed, be the great aim and end of all learning."

But notwithstanding the fact that William Penn defined the problem in 1693 and Benjamin Franklin described a method of solution in 1749, the schoolmen were far from ready to give college recognition to applied science. The reasons for this were carefully explained by Benjamin Franklin in 1789 in his Observations Relative to the Intentions of the Original Founders of the Academy in Philadelphia. In this noteworthy document he tells us that "favors were showered upon the Latin part." For instance, when the trustees met to sign the constitution of the Academy, "the votes of a majority carried it to give two hundred pounds to the Latin master to teach twenty boys, and one hundred pounds to the English master to teach forty."

"On the other hand, the Latinists were combined to decry the English school as useless. It was without example, they said, as indeed they still say, that a school for teaching the vulgar tongue, and the sciences in that tongue, was ever joined with a college."

As a result of this "unaccountable prejudice in favor of ancient customs" Franklin concludes "that the original plan of the English school has been departed from; that the subscribers to it have been disappointed and deceived; that the public had been frequently dissatisfied with the conduct of the trustees, and complained of it; that there has been a constant disposition to depress the English school in favor of the Latin; and that every means to procure a more equitable treatment has been rendered ineffectual; so that no more hope remains while they continue to have any connection. It is, therefore, that wishing as much good to the Latinists as their system can honestly procure for them, we now demand a separation" in order "to execute the plan they have so long defeated, and afford the public the means of a complete English education."

During the century that followed Franklin's efforts at establishing in Philadelphia a type of education that should be "useful as well as ornamental," there have been organized many institutions for this purpose, such as the Society of Mechanics and Tradesmen of New York (1785), the Society for the Promotion of Useful Arts in Washington, the Franklin Institute at Philadelphia (1824), the Ohio Mechanics Institute (1829), Cooper Union (1859), Pratt Institute (1887), Drexel Institute (1893), Armour Institute (1892), and the Wentworth Institute here in Boston.

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From all enterprises of this sort the academic world has stood aloof and remained "nobly mute." Their general attitude is illustrated by the history of the science school at the University of Pennsylvania. In 1816 the Board of Trustees of that institution "created a new department to be devoted to the study of natural science. This department was organized with five professors; and annual courses of lectures to be publicly delivered were required by the regulations. The courses of instruction embraced natural philosophy, botany, natural history, mineralogy, chemistry applied to agriculture and the arts, and comparative anatomy. The support given by the public, however, was not sufficient to compensate for the efforts put forth, the professors were badly paid, and the department soon fell into neglect. It was abolished shortly after the establishment of the Franklin Institute, in 1824, which rendered, it was said at the time, such a department in the University 'unnecessary.'"

It is worth noting in passing that the Franklin Institute was established through the efforts of Samuel V. Merrick; because, having become owner of a workshop in which mechanical knowledge was indispensable to success, he found no means of securing that knowledge in existing institutions. If he secured the necessary knowledge by becoming a mechanic, he would be socially degraded, since in those days people scorned mere mechanics. On the other hand, he was refused admission to the mutual improvement association of mechanics because he was confessedly not a mechanic. He therefore decided to establish a new institution that would meet his own needs. A similar effort had been made the previous year by Professor Keating, who held the chair of chemistry in its application to agriculture and mechanic arts, at the new school of science at the University of Pennsylvania, but this effort had failed. Fortunately, Keating and Merrick combined forces, and this combination of Merrick's need with Keating's knowledge proved invincible. The institution was established. Instruction in science forthwith appeared in the practical work of the world. When science thus acquired the surname of "applied" and became the consort of mechanics, it suffered social degradation, lost college recognition, and was declared by the University to be "unnecessary." Yet because science was thus made accessible to working men, one of them, Thomas U. Walter, then a brick layer, became the architect of the Capitol at Washington.

Numerous instances of this sort might be cited to exhibit the nature of college recognition of applied science, but the following one may be of especial local interest.

In 1847 Abbott Lawrence made a bequest to Harvard College for the purpose of encouraging "the three great practical branches to which a scientific education could be applied." In his letter of instruction concerning this bequest, Mr. Lawrence says: "Mathematics and Chemistry, Geology and Mineralogy, and the other sciences in-

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vestigating the properties and uses of materials employed in the arts; carpentry, masonry, architecture and drawing, are all studies which should be pursued to a greater or less extent in one or all of these principal divisions."

In 1862 Massachusetts received in consequence of the Morrill Act funds for the establishment of a college "where the leading object shall be, without excluding other scientific and classical studies, to teach such branches of learning as are related to agriculture and the mechanic arts—in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

In 1863, in his annual message to the Massachusetts legislature, Governor Andrew strongly urged that the land grant college and the Massachusetts Institute of Technology be united with the Lawrence Scientific School at Harvard for the sake of economy and general efficiency. This suggestion was warmly supported by Mr. William D. Swan on the ground that "Massachusetts may justly claim to be the intellectual head of the country," and that if the State will "so concentrate facilities for education in these departments as to draw hither the highest order of pupils from all other colleges, it will thus furnish professors and teachers for the institutions of other states." In this way alone, "can it develop to the highest degree the intellectual ability of its working classes."

The committee of the Massachusetts legislature, to whom this suggestion was referred, reported that this land grant college should not be connected with any existing institution lest "the manual labor required of its students should be treated with contempt by students of an institution where this labor is not required." The committee also insisted that "instead of the idea of poverty and want being associated with those who labor, that of laziness and worthlessness is associated with those who refuse to work efficiently." As a result of this report, two-thirds of the land grant fund was given to a new agricultural school and one-third to the Massachusetts Institute of Technology.

The conclusion from these facts is obvious. If there were such a thing as college recognition of applied science, the Massachusetts legislature failed to appreciate the fact. The early history of the land grant colleges offers little consolation to anyone who wishes to believe in the educational insight of the colleges in this matter of applied science. Even at the present day such instances as this occur.

A young man in his senior year of a well known high school took a course in electric machinery, in which he was much interested. After graduation, he was enabled on account of this course to secure a good position with an electric light company. In three or four years he had saved enough money to go to the State University and take a course in electrical engineering. When his entrance creden-

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tials were examined, the course in electric machinery was discarded because it was not to be found in the list of approved subjects, notwithstanding the fact that it was this course which gave him the power to earn money to go to college. He was forced to make up this deficiency by taking a year of some real college subject like French.

But if the colleges have held applied science in contempt, it is equally true that the practical and applied science schools have had a no less marked contempt for the colleges.

A forceful expression of this contempt of practical men for the colleges occurs in the pamphlet issued by the Industrial League of Illinois in 1851, when that league was starting the campaign which President James regards as the origin of the Morrill legislation. In this pamphlet Mr. J. B. Turner thus sums up the attitude of industry and applied science toward the college:

"Such systems of culture direct the mind too much towards books, and too little towards facts. The pupil is taught to think of letters and words rather than of things and events. All the way along, from a-b, ab, and long a in hate, and a seven years' war at spelling up through spelling books, grammars and dictionaries, English, Latin and Greek, till he at last took his diploma, it was one everlasting agonism at verbiage, as though God, angels and men—the sky above and the earth beneath, were all moonshine; and spelling, grammar, talk were the only realities in the universe. A real, grammar-school boy of such schools can brave no other idea than that God made the world out of the nine parts of speech, and in English, at least, spelled it all wrong."

"This method does not produce *mind*, but mere *learning*,—not *intellect*, but scholarship—not thinkers, but plausible and sophistical debaters; schoolmen (as of old), who can prove either side of any proposition, but not real men who can discharge the *hard side* of every single duty."

"What we want from schools is, to teach men to derive their mental and moral strength, from their own pursuits, whatever they are, in the same way, and on the same principles, and to gather from other sources as much more as they find time to achieve."

"Can, then, no schools and no literature, suited to the peculiar wants of the industrial classes, be created by the application of science to their pursuits? Why are there more recondite and profound principles of pure mathematics immediately connected with the sailing of a ship, or the moulding and driving of a plow, or an axe, or a jack-plane, than with all three of the, so-called, learned professions together, if it be not intended that those engaged in these pursuits should derive mental culture as well as bodily sustenance and strength from these instruments of their art and their toil?"

"Is there no foundation for the development and culture of a high order of science and literature, and the noblest capacities of mind,

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heart and soul, in connection with the daily employments of the industrial classes? How came such a heathenish and apostate idea ever to get abroad in the world? Was God mistaken when he first placed Adam in the garden, instead of in the academy? Or when he sentenced him to toil for his future salvation, instead of giving him over to abstract contemplation? When he made his Son a carpenter instead of a rabbi? Or when he made a man a man instead of a monk?

It is not here necessary to recall the recent attacks on the colleges from this point of view. We have all seen and heard many of them, and each of us has his own opinions as to their point and their validity. It is, however, perfectly clear that the antithesis which has been defined by the incidents just related has persisted throughout the development of American schools, and is now the underlying cause of such situations as exist in Illinois, for example. Why does the Commercial Club of Chicago fear to have industrial education in that State under the control of the regular school system unless it is because that system is still under the control of colleges which have always been unable to recognize the educational value of applied science? And why do the people still cling to their faith in these impractical colleges, and why do the so-called practical schools ever show a decided ambition to extend their courses upward to college work and to the granting of college degrees? Is it not because they have real though inarticulate misgivings of the educational worth of practical education as now administered?

It thus appears that we are at present confronted by a situation which makes for division rather than for unity in the educational interests of the country. On the one side are the colleges, with their scorn for applied science and for what they call ideals of the market-place, yet struggling to achieve abstract ideals of culture, of mental discipline, of scholarship, or of training for leadership. The edifice which they have constructed inspires awe in the mind of those who believe in abstract ideals. But it has very slender connections with the solid earth and the concrete realities of the daily struggle for bread and wine. Builders of bridges and skyscrapers admire its proportions in a vague sort of way, but fear to enter its portals lest it collapse.

On the other side are the practical schools with their distrust of the abstract idealism of the higher learning and of "high brow" methods, struggling to achieve concrete ideals of improving living conditions, of making production more efficient, of making goods cheap and men dear. They have as yet laid only the foundations of their edifice, but these are broad and deep, and rest firmly on the dignity of labor and the ideality of the daily job. They are trying to plan the superstructure, and are looking wistfully at that of the colleges. Will they copy it? Or will they invent for it a new type of architecture—not Gothic, with its sombre mediaeval soul; nor

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Renaissance, with its wealth of surface ornament; but American, with its rare combination of idealism and practicality?

There is much evidence to show that even now the new type is taking shape. In many places the prophets of America have seen the vision of the future American school. And once having seen the vision, the Yankee can find no rest until he has achieved it, for the soul of the Yankee is his boundless faith that what should be, can be.

Following is the address of Professor Woodhull:—

We sometimes hear it said that one cannot teach applications of physical principles until the principles themselves are understood. I wish to contend that only the converse of this proposition is true. That is, we cannot teach the principles of physics except through an experience with their applications. Of course these principles were first learned by mankind through their manifold applications in nature, and I venture to say that with each one of us teachers of physics it has been true that the principles which we did grasp in our pupil days were those for which we had been prepared by previous experience, and there were many principles taught us which we did not comprehend until later in life when we had met the experience necessary for their comprehension.

In a very real sense one studies physics from his birth to his grave, irrespective of his formal education. The function of the school should be to help the pupil to interpret his experiences. When we find physics very difficult the probability is that we are trying to build without the necessary ground work of experience. The extra-academic study of physics, which each one of us pursues through our experiences during the whole of life, is of vastly greater importance than the formal study of that subject in schools. One may be a master of physics without the formal study, but he can have no comprehension of the subject at all without the projects which grow out of life's experiences. The characteristic of education which has been most often noted is the tendency to teach "fundamental principles," without rooting them in experience.

The person who hangs upon the strap in a street car and has acquired the habit of reflecting upon his experience finds it natural to say when the car starts and he has to tug upon the strap to get himself started, "A body at rest tends to remain at rest." When the car stops and he pulls on the strap in the effort to bring his one hundred and fifty pounds to rest, it is not difficult for him to say "A body in motion tends to continue in motion," and when the car turns a corner he learns by his tussle with the strap that "A moving body tends to continue moving in a straight line."

Projects in physics begin with learning to walk and learning to walk on stilts, learning to skate, to swim, to swing, to teeter, to "snap the whip," to play "duck on a rock," to ride horseback, to ride a bicycle, to sail a boat, to fly kites, to curve a baseball, to play

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billiards, to make water wheels, to shoot, to fish, etc., etc. These projects are invariably studied by the method of "trial and error." These are not pastimes, although they are play. They are very effective studies in physics. They furnish the means for "organizing common sense" according to Huxley's definition of Science.

Let me suggest a new type of college entrance examination for physics: Have the candidate move a heavy log. If he attacks it in the middle and gives up, reject him. If he moves it by lifting at the end, admit him. Have the candidate step on and off a moving platform. If he does it gracefully receive him. If he falls headlong refuse him. Have the candidate discharge a sling. If he hits the mark, admit him to college. If he hits the umpire, condition him. Have the candidate tend a hot air furnace. If he adjusts all the drafts and dampers wisely, admit him. If he shuts the "cold air box" to keep out the cold, as many of his professors do, reject him.

This is the age of machinery, when a majority of intelligent folk would rather know about an automobile than to know much about the college type of physics.

Our so-called thoroughness is rather wooden. One hundred men know about the differential of an automobile; ninety of them know what it is for; nine of them know about its anatomy, and one, knowing what it is desired to accomplish, can design it. The first group are the owners; the second, the chauffeurs; and the last man is the chief engineer at the factory. Each has the knowledge that he needs. It is not necessary to call the first group "smatterers." Some of them are likely to be doctors of philosophy, and hence are supposed not to be victims of "soft pedagogy" or "kindergarten method." If occasion demands additional knowledge, the natural advance is in the order stated above, namely: First, what is it for? Second, the details of its structure. Third, the invention of the device. Teachers of physics sometimes try to reverse this order, and when the inevitable failure results, their subterfuge is to charge the world with lack of thoroughness.

Following these addresses, remarks were made by several of the members present, including Mr. Packard, Mr. Timbie, Mr. Parish and Mr. Butler. Mr. Packard seemed to think that the colleges are ready to consider a more human, applied treatment of science, particularly physics, if only the teachers would say just what they want. Mr. Butler urged the need of making our college preparation consist less in the solution of mathematical problems, and more in the development of powers of reasoning, observing and interpreting phenomena of every day life.

ALFRED M. BUTLER, *Secretary.*

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PROGRAM OF THE SEVENTY-THIRD
REGULAR MEETING

OF THE

Eastern Association of Physics Teachers

Saturday, March 11, 1916

at Wentworth Institute, Boston, Mass.

9.30 A.M. Meeting of the Executive Committee.

10.00 A.M. Business session.
Election of officers.
Reports of Standing Committees.
Election of New Members.

11.00 A.M. Address, "The Phonetoscope, a New Instrument for Detecting Sounds." Prof. A. G. Webster, Clark University.

11.45 A.M. Address, "Electrical Transmission of Power." Mr. Henry I. Harriman, President of the Connecticut River Transmission Company.

12.30 P.M. Lunch at the Art Museum Restaurant.

2.00 P.M. Inspection and demonstration of the "Choralcelo" magnetic piano player, at the works of the Choralcelo Co., 100 Boylston Street.

3.30 P.M. Inspection trip and demonstration of the "Aeroplayer," at the works of the National Piano Factory, 621 Albany Street.

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MORNING SESSION

The meeting was called to order by President Clarence M. Hall, who presented to the Association Principal Williston of Wentworth Institute. Mr. Williston expressed his great pleasure at welcoming the Association to the Institute, and called attention to the many changes in the way of extension of courses, new buildings and improved conditions generally, urging those present to inspect the plant carefully, and express approval or disapproval, according as they were impressed.

Mr. Hall then called for the

Report of the Treasurer.

Receipts.

Balance, March 20, 1915	$210.68
Dues	251.00
Lunches	92.00
School Science	67.50
Scientific American	36.80
Popular Mechanics	12.50
Popular Electricity	3.00
	$673.48

Expenses.

Printing, postage, etc.	$260.25
Secretary's salary	50.00
Expenses of meetings	22.30
Lunches	100.00
School Science	67.50
Scientific American	36.80
Popular Mechanics	12.50
Popular Electricity	3.00
Balance on hand	121.13
	$673.48

Respectfully submitted,

PERCY S. BRAYTON, Treasurer.

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This was followed by the

Report of the Secretary.

During the past year there have been the customary three regular meetings, with a smoker on the evening before the fall one. No meetings have been held in Boston. The annual meeting was held on March 20 at the Medford High School. The topic for discussion was, "What Should be the Aim of High School Physics Teaching, as Considered from the Viewpoint of Religion, Labor, the College and the Engineer." Men prominent in these lines of thought spoke before the Association.

On May 22 we were the guests of our Vice-President at St. Paul's School, Concord, N. H. Here addresses on "Advanced Progress in X-ray Work" and "Long-Distance Telephones" were given by experts in the subjects. Interesting methods of projection were also shown. The trip afforded a splendid opportunity to inspect a large private preparatory school, as well as give members a breath of country air and life.

On December 4, an innovation in the form of a trip to the repair shops of the Boston & Maine Railroad, at Billerica, took us again away from Boston. The day was all too short to see the many points of interest this visit afforded, and our hosts outdid themselves in their efforts to make the meeting an instructive one.

On Friday evening, December 3, at the Boston City Club, we had our annual smoker. Our guests of the evening were Dr. Mann, Professor Hall and Professor Woodhull, who spoke to us on "College Recognition of Applied Science."

The present membership is 80 active and 68 associate members, an increase of four.

Respectfully submitted,

ALFRED M. BUTLER, Secretary.

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Following is the

Report of the Committee on Current Events.

Roger C. Chittenden, Chairman.

Fredrick A. Kolster of the U. S. Bureau of Standards has invented a simple device for ascertaining the direction from which radio messages come. The form of the instrument is a Government secret and regarded as extremely important, not only as a means of finding an enemy fleet, but in obtaining the direction of lighthouses in a fog; in coast-guard work; detecting amateur stations, etc. The instrument is small enough to be carried by a single observer.

The Chicago, Milwaukee and St. Paul R.R. has ordered fifty electric locomotives for use over the Belt, Rocky and Bitter Root Mountains. Each locomotive weighs 260 tons, is 112 feet long and develops 3440 H.P. They will haul 2500-ton trains over a 1% grade at 16 m.p.h., or 800-ton passenger trains at 60 m.p.h. They are fitted with D.C. motors, taking 3000 volts. Separate motors are twin-geared to each of 8 pairs of driving wheels, spaced at 10-foot intervals. Each driver is 52 inches in diameter. Each locomotive costs $100,000. Four hundred miles of main track and 100 miles of spurs and side-tracks are electrified, great economy being effected in the abolition of yards and round houses.

The American Radio and Research Corporation at Tufts College has completed its 304-foot tower, and is ready for advanced research work in its little laboratory. The tower measures 3 ft. 6 in. square at the base.

A French scientist has invented a microscope using x-rays.

The Animal Rescue League of Boston kills its stray animals by electricity.

The Committee on Current Literature has no report to hand in at this time.

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For the

Report of the Committee on New Books,

Mr. C. E. Stratton read a criticism of "A First Course in Laboratory Physics for Secondary Schools," by Millikan, Gale and Bishop. Ginn & Co. 1914. 135 pages. Price, cloth, 50 cents.

This book presents a course of about 50 different experiments and 12 alternative ones of the type ordinarily suggested by the average secondary school text.

Each experiment contains its own introduction, so that it would be possible for the pupil to perform the experiment without any previous study of the subject under discussion.

The experiments are divided as follows:

Two on measurement.

Four on density and Archimedes' principle.

Five on fluid pressure, including two alternatives.

Thirteen on heat, including three alternatives.

Six on mechanics, including one alternative.

Eighteen on electricity, including five alternatives.

Four on sound.

Eleven on light, including one alternative.

The experiments on practical transformations of energy have been given an important place and are exceptionally well treated.

The form for the recording of data, which accompanies most of the experiments, would seem to be an aid to both teacher and pupil.

The 7½ by 10 inch pages are approximately the same as that of the ordinary loose-leaf note-book, and the book can be obtained in this form in the Biflex binder for 80 cents.

Committee on New Apparatus,

R. C. Lowell, Chairman.

Mr. Andrews showed simple apparatus for laboratory experiments in acoustics. These consisted of pasteboard mailing tubes of different length to be used in the study of resonance, and open and closed pipe effects. By means of a sliding paper tube inside, the length of the air column could be varied, and from the length of the tube when resonance is secured, the wave length of any particular pitch could be calculated.

Mr. Black showed a bicycle pump modified with metal cap in place of a handle, to be used to show the compressibility of air as contrasted with the incompressibility of water. Hammer blows on the piston top produced no motion when the cylinder was filled with water. With the cylinder filled with air, the resilience of the air column was very marked.

Mr. Lowell showed Knott's new model of the hand-power dynamo. This is with the gear in oil casings, to reduce noise and

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friction. It is rated at 5 amperes, 20 volts, 100 watt capacity at 200 R.P.M. Two turns of the crank per second produces this result. The cost is $40.

Knott also is to put out a static machine with 12-inch plates with the same type of drive.

Mr. Schuman then described laboratory experiments on the Davis truss as carried out at Wentworth. The end supports are A and F. The four joints between them are B, C, D, E. The two supporting legs rest upon platform balances on the floor, at each end.

Procedure: 1. Determine the load carried by each scale, with no weights added to the truss. From this compute the total weight of the truss and supporting legs. Also determine the position of the centre of gravity of the whole.

2. Apply loads of from 10 lbs. to 50 lbs. on the points A, B, C, D, E, and F, and compute the loads carried by each scale.

3. Take the scale readings and check computation.

4. Repeat four times, using different combinations of loads each time.

On recommendation of the Executive Committee, the following were unanimously elected members of the Association:

Active:

J. Richard Lunt, English High School, Boston, Mass.
C. E. Allen, Country Day School, Newton, Mass.

Associate:

Richard Payne, High School, Greenfield, Mass.
Eugene H. Powers, Classical High School, Worcester, Mass.
Ruth E. Thomas, High School, East Boston, Mass.

The following officers were elected for the year 1916-1917:

President, Clarence M. Hall, Springfield.
Vice-President, Frederick E. Sears, St. Paul's School.
Secretary, Alfred M. Butler, Boston.
Treasurer, Percy S. Brayton, Medford.
Executive Committee: W. E. Richmond, W. H. Timbie, C. H. Andrews.

Professor A. G. Webster, of Clark University, Worcester, Mass., then gave a most instructive address on "The Phonetoscope." Although stenographers were supposed to take this address, the result of their work was most unsatisfactory, and the copy is being sent to Professor Webster for revision. An effort will be made to get this back in time to present it in the report of the next meeting.

Through unavoidable changes in his plans, Mr. Harriman was unable to be present to address us on "Electrical Transmission of Power."

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AFTERNOON SESSION.

At the National Piano Factory.

Those who availed themselves of seeing a piano player in the process of construction were shown the interior workings, and parts that go to make up this instrument. The particular feature of the Aeroplayer is that the air chambers, where the valves that operate the separate notes are located, are made of metal in one piece, so that there is no opportunity for seams to open with changes in atmospheric conditions. Thus the partial vacuum is maintained continuously. We were most hospitably received by the management, each receiving a descriptive catalogue of the Player.

The meeting closed with a visit to the parlors of the Choralcelo Company, on Boylston Street. Here, after a brief description of the instrument, a recital was given to show what can be done with it. This instrument is an electrically operated contrivance built around a piano. The piano forms one of four units, which furnish respectively the strings, horn, organ, flute and oboe effects of the orchestra. All the vibrating media are set in vibration by means of electro-magnets, through which an intermittent current passes. This current pulsates in accordance to the vibration frequency of the note desired. The differences in effect produced lies in whether wires or air columns are set in vibration, and in the latter case, the shape of the vibrating air column, which acts as a resonator to a vibrating solid.

The source of power is the city lighting circuit, A. C. or D. C. This sets in action a motor generator set, from the dynamo of which 30 volts D. C. is secured. This source serves to set the electro-magnets in operation as well as run an eight H.P. motor, which, through gears, runs twelve discs. These discs revolve at different speeds corresponding to the ratios expressed in the equally tempered chromatic scale, the ratio of successive notes being 1.05946. Each disc has six circles of commutating segments, each successively having twice as many segments as the one inside it. These furnish the six octaves represented on the keyboard of a piano. On these discs press brushes, each one of which is connected with its proper note on the keyboard. In this manner any electro-magnet of any unit may be set in action by an intermittent current, provided the stop of the desired unit or combinations of units is brought into play. There are stops above the keyboard, similar to those on an organ, which when thrown in produce many different effects.

The strings of the piano are set in vibration either in the ordinary way, by means of the keys, causing the hammer to strike them, or, if a pedal is pressed to throw out the striking mech-

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anism, by means of electro-magnets, one behind each set of strings for a note.

The steel wires are intermittently attracted and set in vibration. In the case of the wind instruments, consisting of straight-sided wood and metal pipes, conical pipes and pipes with flaring tops, plates at the bottom of the vertically-placed pipe are set in vibration by magnets. These plates are on the vibrating-plate form, as in the xylophone, of different lengths according to the pitch desired. The air columns act as resonators, and increase the volume of the sound waves of the vibrating rods.

Through a resistance controlled by the operator, the strength of the current flowing through the magnets may be varied, and thereby the amplitude of vibration and resulting loudness of the sound varied. The sound swells without the use of a swelling chamber, as in the organ.

The instrument is a very wonderful one in that a multitude of combinations can be secured, depending upon the skill of the operator.

The cost of the apparatus varies from $1500 for piano with one other unit, to $10,000, in which all possible effects are attainable. It is accessible, therefore, only to persons of means with large homes, or for theatres, churches, or places of amusement. Filene's Store in Boston has one that cost in the neighborhood of $5000.

The machine may be seen in operation at the showrooms, 585 Boylston Street, Boston, Mass.

ALFRED M. BUTLER, Secretary.

NOTICE.—Through the courtesy of Longmans Greene Co., the secretary is in possession of forty progressive sets of three-color prints. Each set consists of five prints, one each of the red, yellow and blue impressions, one of the red and yellow together, and one of the finished print. These sets will be sent gratis to the first forty members of the Association who send a request for them to the secretary.

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PROGRAM OF THE SEVENTY-FOURTH
REGULAR MEETING
OF THE

Eastern Association of Physics Teachers

Saturday, May 13, 1916

at the High School of Commerce, Boston, Mass.

9.30 A.M.
Meeting of the Executive Committee.

10.00 A.M.
Business Session.
Reports of Standing Committees.
Election of New Members.

10.30 A.M.
Address, "Electrical Transmission of Power." Mr. Henry I. Harriman, President of the Connecticut River Transmission Company.

11.30 A.M.
Address, "The Interrelations of Physics and Electrical Engineering." Dr. A. E. Kennelly, Professor of Electrical Engineering, Graduate School of Engineering, Harvard University.
Discussion of Dr. Kennelly's paper.

1.00 P.M.
Lunch. At a restaurant near the school.

2.00 P.M.
Description and Demonstration of a New Lecture Table Oscillograph. Mr. H. T. Crane and Mr. C. L. Dawes, of Harvard University.

3.00 P.M.
"The Laboratories of the High School of Commerce." Mr. Francis E. Mason.
Inspection of Laboratories.

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THE SEVENTY-FOURTH MEETING

MORNING SESSION.

The meeting was called to order by President Hall, who called for the

REPORT OF THE COMMITTEE ON NEW APPARATUS,
Mr. C. R. Herrick, *Chairman.*

Mr. Herrick showed first a worm gear that was made by pupils of the Everett High School. Solid and durable; this can be used with large weights.

Experiments to determine the heat equivalent of electricity and the heat of vaporization of water may be performed with a 500-watt instantaneous electric water-heater and a thermos bottle. The loss of heat by radiation is eliminated.

A copper metallic dial thermometer with glass back is put out by the Palo Company, of 90 Maiden Lane, New York. The catalog of this company is interesting.

Mr. Herrick showed a modified form of U-tube manometer. One end is so arranged that it may be open or closed by means of a cap screwed to the end of it. The other open end extends through two enlargements in the form of bulbs, one over the other, the opening being at the bottom instead of the top. The apparatus stands about a foot high when mounted. With this, pressures as high as sixty pounds can be measured.

The latest form of Standard Scientific Company apparatus for determining the index of refraction of water is simple and accurate.

The Farwell Stifler optical bench put out by the Standard Scientific Company offers a quick interchangeable outfit for demonstration of reflection and refraction phenomena.

Mr. Harrington told of a boiler and dynamo test made at the Newton Technical High School lasting a school day. From data secured curves were drawn. The result of these was interesting as showing the drop in current and engine output at recess, when the boiler pressure and speed increased.

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Following is the report of the

COMMITTEE ON CURRENT EVENTS IN PHYSICS,
F. A. Sheldon, *Chairman.*

Germany is applying her scientific knowledge to solving the problem of how to make her crippled veterans useful members of society. A recent number of the *Boston Transcript* gives a résumé, with cuts, of an article in the *Elektrotechnische Zeitschrift*, in which Professor Klingenberg describes various forms of an iron hand which can be strapped to the stump of an arm and magnetized by switching an electric current into it. The magnet is supplied with current through a flexible cord and plug, the switch being operated by the foot or some other part of the body. A portable battery may be used when the man is working too far away from the regular electric installation.

A certain amount of movement is provided for by a ball and socket joint, which can be clamped to a fixed position or left free to move with a certain control by friction. With this apparatus all articles made of iron, like files, screw drivers, bits, pincers, etc., can be held firmly and used for an indefinite time. Tools made of wood, or material other than iron, can be fitted with iron plates or bands which will permit them to be held firmly by the magnetic hand. Professor Klingenberg is devoting his time to developing this device, and much is expected of it, as thousands of Germany's skilled workmen are crippled by the accidents of war.

Charles Vaillant, chief of the radiographic laboratory in Paris, announces a successful method of making x-ray photographs directly upon sensitized paper, instead of upon a glass negative, thus saving weight and space and about one-twentieth of the cost. M. Vaillant has suffered the loss of all but two fingers and a thumb out of the original ten, and says that he intends to make his discoveries pay for his amputations. One of his latest discoveries is a method of determining by an x-ray photo whether an infant was born dead or alive. If born dead, the negative is perfectly dark; if the infant lived an instant, the plate shows the stomach first and then the lungs, according to the duration of life.

The first one of a fleet of power boats made recently a successful trip between St. Louis and New Orleans, which initiates what may be a revival of successful water transportation along the Mississippi River. The type of boat seems to be new to American waters, though more common in Europe. The barge is 240 ft. long, 43 ft. wide, and draws 7½ feet of water. It is driven by four 3-cycle, 80-horsepower internal combustion engines, using kerosene for fuel. Its cargo is handled by an electric crane, and it carries a wireless equipment which was able to keep in touch with St. Louis throughout the complete trip to the Gulf. The boat is controlled by

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electricity, and uses the current for cooking and heating purposes. It is a thoroughly modern type of boat and much is expected of the fleet, which began regular trips on May 13.

On May 17, the Franklin Institute of Pennsylvania awarded its two honorary medals for 1916. One went to Prof. Theodore W. Richards of Harvard University, "in recognition of his numerous and important contributions to inorganic, physical and theoretical chemistry." The other was conferred upon John J. Carty, E. D., chief engineer of the American Telephone and Telegraph Company "in recognition of his long-continued activities in the telephone service and his important and varied contributions to the telephone art."

Following is the report of the

COMMITTEE ON MAGAZINE LITERATURE,
G. H. Boyden, *Chairman.*

MECHANICS.

Scientific American. March 25, 1916, p. 322, "The Coal Dust Locomotive." April 8, 1916, "The Extreme Range of Modern Guns," Alston Hamilton.

LIGHT.

Scientific American Supplement. March 25, 1916, p. 194, "Light and Illumination," I, Steinmetz. March 25, 1916, p. 218, "Light and Illumination," II, Steinmetz.

ELECTRICITY.

Scientific American. March 18, 1916, p. 298, "Electric Traction over the Great Divide." March 25, 1916, p. 323, "Unit Design in Wireless Telegraphy."

Scientific American Supplement. May 6, 1916, p. 290, "Radiations from Atoms and Electrons," I, Sir J. J. Thompson. May 13, 1916, p. 306, "Radiations from Atoms and Electrons," II, Sir J. J. Thompson. May 6, 1916, p. 300, "Great Electro-magnets," I. May. 13, 1916, p. 316, "Great Electro-magnets," II. May 13, 1916, p. 302, "Effects of Electrolysis on Underground Piping Systems."

UNCLASSIFIED.

School Science and Mathematics. April, 1916, p. 139, "The High School Physics Library," Rendtorff.

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On recommendation of the Executive Committee the following were unanimously elected members of the Association:

Active:—

F. M. Boyce, Phillips Andover Academy.
Francis Clough, High School, Dedham, Mass.

Associate:—

W. A. Clifton, Rogers High School, Newport, R. I.
C. L. Harris, High School, Concord, N. H.
G. W. Vail, High School, Scituate, Mass.

Mr. Henry I. Harriman, President of the Connecticut River Transmission Company, then delivered an address on,

"Electrical Transmission of Power."

He said in part that the great efforts today tend toward conservation and efficiency. These deal with the creation of effort and the applications of energy (generation and application of power).

The use of water-power in New England dates back to seventy-five years after the landing of the Pilgrims, when the first water wheels were made. These were used mostly for the grinding of corn. With the invention of the cotton-gin there was an increased demand for water-power, and plants sprang up in the South extensively. With the beginning of the Nineteenth Century there arose a demand for power for other purposes than grinding flour, paper-making and the cotton-gin. Up to 1850, ninety per cent. of the industries were run by water-power.

New England, because of its rugged soil, was not suited to agriculture, so the trend was to manufacturing. Factories were built near waterfalls, and here, about the factories, grew up the large cities. Great manufacturing centers appeared around waterfalls, since it was not possible to transmit the power to any great distance. Manufacturers moved to the power. The universal use of water power extended to the end of the Nineteenth Century. With the introduction of the steam engine, there was a tendency for some manufacturing establishments to move to the seacoast cities, where labor was cheap and accessible.

With the arrival of the Twentieth Century and the development of electrical power, a change took place, and power moved to the manufacturer. Great electrical distribution systems were developed in the Western and Southern States. Electricity has been transmitted as far as two hundred and fifty miles, from the Sierras to San Francisco and Los Angeles. In the South, the manufacturing centers of North and South Carolina were linked by electrical transmission systems.

Fewer sections of the country offer better opportunities for

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transmission of electrical power than does New England, with an area of 60,000 square miles, and an average elevation of 900 feet above sea level. Fifteen million horsepower of energy is possible from falling water for 300 days of the year; an equivalent of fifty million tons of coal. Of this, ten per cent., or five million horsepower, can be developed. The industries of New England can use all that can be developed, and with the possibility of transmitting this power electrically settled, localities within a radius of 200-300 miles of the water-power can be supplied.

The applications of electrical power are many, as instanced by the electrification of parts of the New Haven Railroad; the 400-mile stretch of the St. Paul west of Butte, Montana; the electric furnace which uses more electricity than is used for lighting the five largest cities in the country, in manufacturing abrasives and in the fixation of atmospheric nitrogen for nitrates. Of the one and a half million horsepower used in New England, one million will eventually be furnished by electric power companies, which get their electricity from water-power.

In developing electric power from water-power the great difference between maximum and minimum flow of the river requires the building of storage reservoirs, secured by the construction of dams. In this way the development of power at the head waters of the streams is very greatly increased, and the human effort thus conserved amounts to the setting free of thirty thousand men, whose efforts can be diverted to other channels of work.

The utilization of water-power thus stands on a par with the other great inventions and achievements of the age.

Mr. Harriman then showed, by means of a number of slides, the various power-houses and distribution centers of the Connecticut River Company. The largest plant is just below Brattleboro, Vermont, with five other branch plants on the Connecticut and Deerfield Rivers.

In these power houses the vertical and horizontal forms of turbo-generator are used, according as there is a tendency of the water to rise and flood the power-house. The horizontal form is, of course, the more efficient, as the weight is more evenly distributed on several bearings.

Generators of 2500 kilowatt capacity are used, eight in a power-house. Owing to the high voltage the real switches are not on the switchboard. The switches on the board simply control the real switches, which are in compartments well insulated from each other.

In the construction of a dam in a large, deep river, part of the river is cut off by means of a coffer-dam, formed by first lowering a crib-dam weighted with rocks, the side composed of matched boards. The water inside is pumped out, the river bed scooped

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out to bed rock, and the dam of concrete built on this. Where water flows over the dam the surface is of stone, but other parts of the dam are of earth. Earth dams are of the clay-core type, in which the center is of clay and the edges of gravel. Trestles are built at the extreme edges of the base of the dam, and a mixture of clay and gravel dumped from them. A stream of water five times the size of a fire hose is played upon the inner edges of the two piles, thus forcing the clay to the middle part. On top of this, second trestles are built, nearer together, and further dumping of gravel and clay follows, with a washing of the clay into the narrower space between the trestles. As the dam rises, the sides slope to the summit, where a single trestle serves for the last dumping. The gravel surface acts to hold the clay-core in place.

For the transmission lines, which carry power to cities over two hundred miles away, a right of way across country is secured, and a space one hundred and fifty feet wide is cleared. Towers are placed five hundred feet apart, and from them are suspended two circuits of three wires each, for the three-phase system. Suspended disc insulation is used, rather than the pin type. As the voltage becomes higher, the number of series of suspended discs is increased. For a 110,000 volt transmission, seven discs are used. The wires are one inch copper, except on very long spans, such as the two thousand foot one across Wachusett Reservoir. Here iron cable is used, as the copper is not of sufficient tensile strength. The wires must not be less than ten feet from each other.

Dr. A. E. Kennelly then spoke informally on,

"The Interrelations of Physics and Electrical Engineering."

After mentioning the great applications of physics in our many walks of life, and its international aspect, Dr. Kennelly made a strong plea for the abolishment of the old antiquated English system, and the substitution of the metric system, both in science, in manufacturing, and in our daily life. England and the United States are the only ones of the civilized countries that do not use the metric system in general. The reason that there has been no change is the cry of the manufacturers that it would entail great losses, due to the discarding of machinery that has been made from the standpoint of the English system. This argument he showed to be wrong, as evidenced by the experience of France, when the change was made there.

The great argument in favor of the metric system lies in its extreme simplicity. Dr. Kennelly, in his classes, dictates his problems in the English terms, but requires that they be changed to metric, the problem to be worked out in this system, with metric formulae, and the result again changed back to the English system.

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Dr. Kennelly's remarks brought out a renewal of the discussion twice before brought before the Association, in regard to the abolishment of the dyne and erg from our physics instruction. Mr. Andrews is strongly in favor of the metric system and the absolute system as well. Mr. Timbie, while not against the metric system, feels that we should teach in the terms with which the pupil is familiar, and that the burden of teaching the metric system should not fall on the physics teacher. Dr. Kennelly then showed a steel rule 10 centimeters long, one centimeter wide, and one millimeter thick. With this the unit of length can be understood. The volume of it is one cubic centimeter. The weight of it states in grams the weight of one cubic centimeter of iron.

Mr. Packard feels that we have no right to teach the metric system to our pupils since they do not encounter it in their daily life.

AFTERNOON SESSION.

Messrs. H. G. Crane, C. L. Dawes and J. A. Roy of Harvard University demonstrated a new type of lecture room oscillograph, which has been recently devised by them. The instrument is capable of projecting upon a screen many of the transient phenomena which occur in electric circuits.

Fig. 1 shows the vibrators of the instrument. Each vibrator

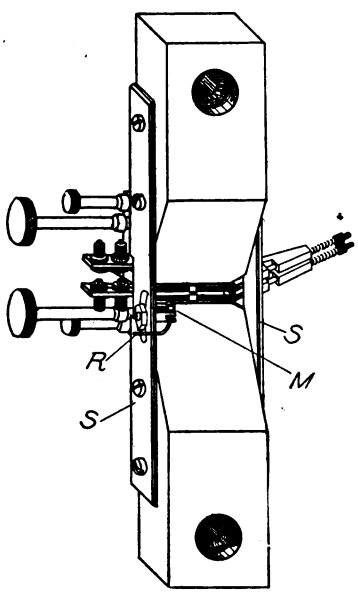

FIG. 1.—Vibrators and detachable pole-pieces assembled.

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consists of a small phosphor-bronze filament which passes from one binding post over two ivory supports and back again, to the other binding post. It is held in tension by a small spring shown in the figure. At the center of the filament a very small mirror is cemented. The vibrators are then placed between the poles of an electro-magnet. Knurled adjusting heads turn the vibrators about either horizontal or vertical axes, thus making it possible to bring the spot of light reflected from the mirrors to the desired position upon the screen. When the current flows through the filament, the two portions across which the mirror is cemented, move in opposite directions, thus turning the mirror. Because of the small inertia of the filament and mirror, it is able to follow very rapid variations of current.

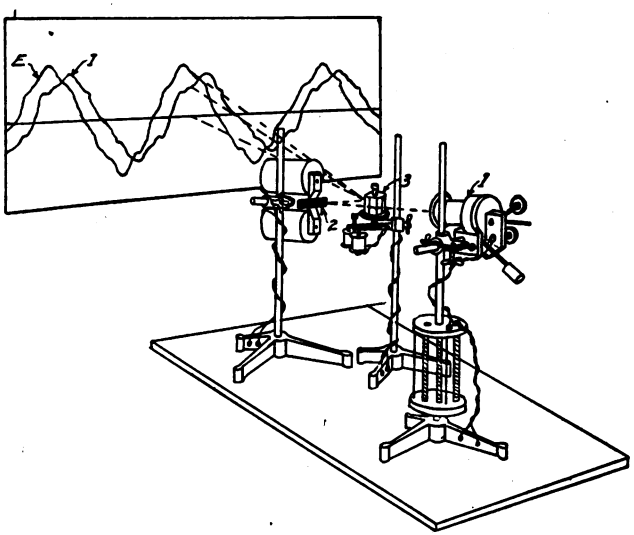

FIG. 2.—Mounting and general arrangement of oscillograph when in position for operation.

A beam of light from a specially designed arc lamp (1, Fig. 2) strikes the vibrating mirror (2), and a straight and vertical band of light results. This vertical band of light strikes the rotating mirror (3), which draws it out and projects it upon a screen, so that the wave form of the current passing through the filament is sketched accurately on the screen, where it may be easily seen and studied. In order to show voltage and current simultaneously, as shown in Fig. 2, two vibrators are used. The one which shows the voltage wave is connected directly across the line in series with a high non-inductive resistance, and the one which shows the current wave is connected in series with the line, but is shunted by a low resistance shunt, especially designed for this instrument.

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In order to project a zero line on an axis of reference, a small fixed mirror M (Fig. 1) is used. This is so mounted that the beam of light coming from it can be brought to its proper position by the small curved rod R. The pole pieces are held together by the two brass straps S S. The pole pieces are bolted to the cores of the electro-magnet shown in Fig. 2.

By means of the instrument, alternating current phenomena were projected upon the screen. It was explained that these phenomena, occurring but sixty times per second, could be held stationary upon the screen, provided that the rotating mirror could be kept in synchronism with the waves. This is accomplished by a small synchronous motor designed by Mr. Crane, which drives the mirror through a gear.

The effect of connecting resistance, inductance and capacity in the circuit, as well as their effect upon making the current lag and lead the voltage, were shown. Also such phenomena as the current variations in the ordinary electric door-bell, when rung from a battery and from a bell-ringing transformer, were shown. The oscillograph was also able to show the phenomena of the alternating current arc very plainly. It was observed that, although the current passing through the arc followed very nearly a sine curve, the voltage across the arc was flattened at the top, showing that a back electro-magnetive force exists in the arc.

Mr. Dawes then explained that, although no difficulty was encountered in designing a vibrator capable of following these 60-cycle waves quite accurately, for frequencies of the order of 1000 to 2000 cycles per second, such as occur in telephone circuits, the design was more difficult because the inertia of the moving parts must be made very small and the sensitivity very high. The high sensitivity is necessary because the power available in a telephone circuit is limited. If the inertia is not made very small, and if the filament is not kept at considerable tension, the vibrator will superpose its own mechanical frequency of vibration upon the electric waves it is trying to show. A vibrator capable of responding accurately to these high frequencies has been designed, however.

In the demonstration this vibrator was first used to show transient phenomena such as occur in a direct current circuit. By means of a synchronous contactor, which opens and closes the circuit continuously and in synchronism with the rotating mirror, direct current transients may be made to recur, so that they are shown as stationary waves upon the screen.

The logarithmic rise of current in an inductive circuit was first shown, as well as the effect of varying the inductance. This was followed by connecting resistance, inductance, and capacity in series and the charging and discharging the circuit by means of the contactor. Under these conditions the charge and the discharge

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will be oscillatory, as shown in Fig. 3, provided that R, the circuit resistance of the circuit, is less than $\sqrt{\frac{4L}{C}}$ where L is the inductance in henrys and C the capacity in farads. The discharge curve is similar to the charge curve of Fig. 3, except that it is

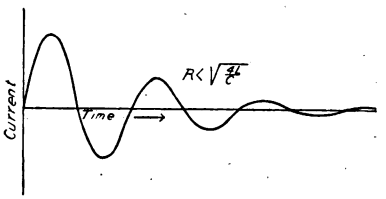

FIG. 3.—Oscillatory charge or discharge of an electric circuit.

reversed. This type of oscillation occurs in radio-telegraphic sending and receiving circuits, although their frequency is higher than that obtained here. This makes the instrument very useful in connection with instruction pertaining to radio-telegraphy. Fig. 3 represents a damped oscillation. If the resistance of the circuit be increased, the damping increases until the oscillation ceases altogether, and a charge and discharge similar to Fig. 4 are obtained.

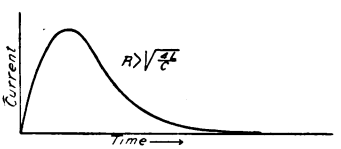

FIG. 4.—Non-oscillatory charge or discharge of an electric circuit.

This special high frequency vibrator was then connected in series with a telephone transmitter, and various sounds were produced in the transmitter, vocally, by means of a tuning fork, by an organ pipe and with a Victrola phonograph. The vibrator showed the fundamentals, overtones, etc., which were produced by the sound-producing devices. It also showed that the telephone transmitter distorts the sound waves, when converting them into electric waves for transmission purposes. Therefore the sound given out by the telephone receiver may be materially different in tone and quality from the original sound.

A complete description of this oscillograph may be found in the *Electrical World*, February 19, 1916, and in the *London Electrician*, March 31, 1916.

Following this the laboratories of the High School of Commerce were open for inspection.

ALFRED M. BUTLER, *Secretary.*

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